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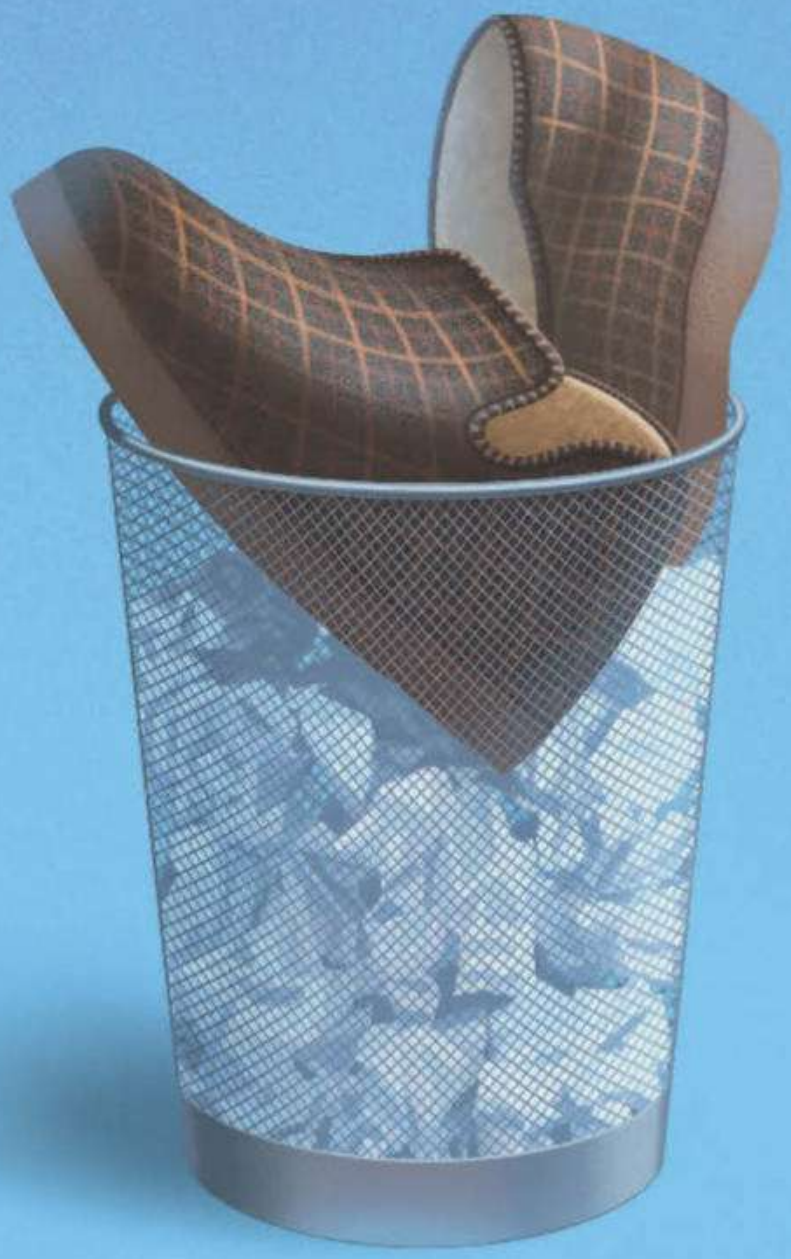

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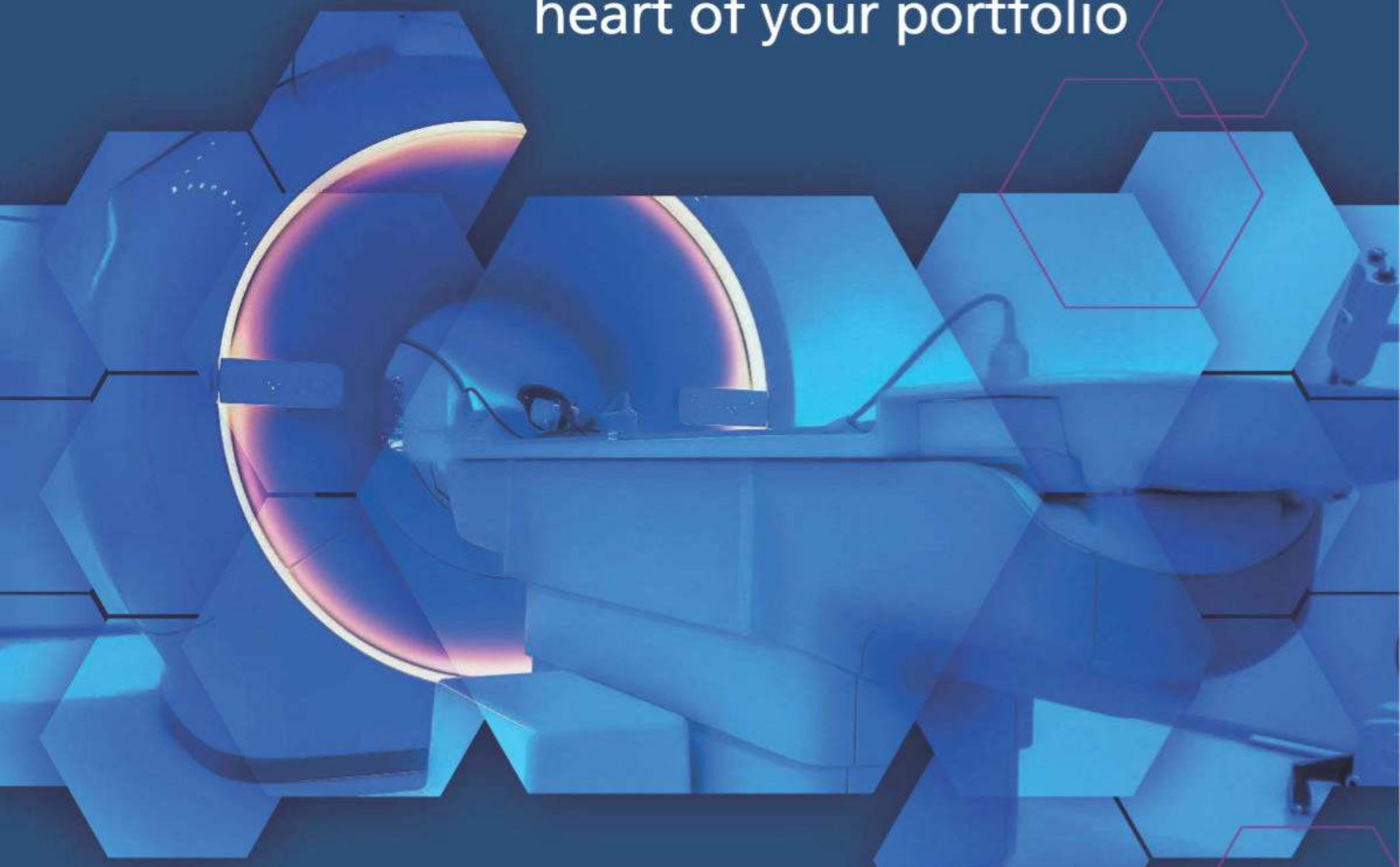

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Deep carbon

Hear geologist Tamsin Mather explore the connection between volcanoes and climate change, highlighting how volcanic activity affects Earth's carbon cycle. She will also discuss the role volcanoes could potentially play in future climate solutions via geothermal energy and resource extraction. Find out more at New Scientist Live on 12 October at London's ExCeL Centre.

newscientist.com/nslmag

Tour

Geology, conservation and culture: Vietnam

Experience tropical jungles, limestone caves, blissful villages and feats of underground engineering in this tour of Vietnam's spectacular geology, wildlife conservation and history. Immerse yourself in local culture and cuisine – from street food to dining like royalty. This 13-day tour begins on 17 August and costs £3699.

newscientist.com/tours

Podcast

Dead Planets Society

In the latest episode of this absurd and occasionally cataclysmic podcast, *New Scientist*'s Chelsea Whyte and Leah Crane ask what would happen if we brought back geocentrism by enlarging Earth and turning it into a black hole. Hear why we would only be king of the universe for a very, very short time before all hell broke loose, as planets, stars and galaxies hurtled towards us.

newscientist.com/nspod

IRINA DMITRIENKO/ALAMY

Engines of the cosmos Getting to grips with enigmatic black holes

SHUTTERSTOCK/SATORIPHOTO

Halong Bay Take a boat ride among Vietnam's limestone outcrops

Video

Typhoon survivors

Dreams of the Ravaged is a short film about the tropical cyclone that hit the Philippines in 2021 and killed over 400 people. The film, directed by Breech Asher Harani, recently won the New Scientist Editors Award at the Earth Photo 2024 competition. Harani captures the lived experience of a natural disaster through interviews, news reports and animation.

youtube.com/newscientist

Newsletter

Launchpad

From the smallest to the biggest black holes, find out how these extreme matter-engulfing beasts shape the universe at every scale. Discover why primordial black holes offer a solution to the problem of dark matter and how distant supermassive black holes are rewriting our universe's evolutionary history.

newscientist.com/launchpad

Video

"Extreme weather unlike any we have seen before affects our lives in ways we will never forget"

Summer sale

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Live long and prosper?

The downsides of anti-ageing medicines won't outweigh the benefits

THE field of anti-ageing medicine has exploded in recent years as discoveries about the fundamental biology of ageing are translated into experimental therapies. The latest fountain of youth to gush from the lab comes in the form of vaccines against age-related conditions – cancer, heart disease, dementia and more. The first of these could be available by the end of the decade. All-purpose anti-ageing jabs are also in development (see page 32).

The upsides of such vaccines are clear. Anything that limits the impact of age-related conditions on people who live into old age – not to mention on the loved ones who often end up caring for them – has to be welcomed. They also promise to make a dint in the increasingly debilitating societal and economic costs of these diseases.

But as with all anti-ageing interventions, there are potential downsides too. If millions of people live significantly longer, we risk a population explosion on a planet whose resources are already overstretched. If the vaccines merely delay the onset of age-related conditions, they will only postpone the burden on people and society. And as Nobel prizewinner Venki Ramakrishnan told us earlier this year, a long-lived society is likely to be a stagnant one.

"If vaccines and other anti-ageing therapies are effective and affordable, they will be used"

These are familiar fears. The stock answer is that the goal is increased healthspan. That means people living for longer, free from the diseases of old age, then suddenly declining and dying.

That's the idea, at least. We won't know the outcome until the therapies have been rolled out at scale, at which point it will be too late to put the genie back in the bottle. But that isn't really an option anyway. If vaccines and other anti-ageing therapies work and are affordable, they will be used.

Besides, nobody would argue that innovations like antibiotics, vaccines and advanced diagnostics were a bad idea even though they ushered in our era of age-related diseases. Similarly, we shouldn't fear life-saving medical advances on the basis of unintended consequences. If we can make lives longer and less painful, the downsides are a price worth paying. ▮

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NewScientist

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- **Live link-up with remote telescope in Australia to view the southern hemisphere's night skies.**
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newscientist.com/universeweekender

News

Life for Mars
Moss that survives extremes could live on the Red Planet **p9**

Insect amputation
Ants chew off each other's legs to stop infections **p11**

Writing's on the wall
Ancient Egyptians had bad posture at work too **p16**

Going deep
Ultrasound device can stimulate hidden brain structures **p18**

Knight school
AI learns what entertaining moves are in chess **p19**

PIERRE MARKUSE/COPERNICUS SENTINEL

Earth science

Staring into the eye of a hurricane

This is the awe-inspiring eye of Hurricane Beryl as it moved over the Caribbean on 1 July. The eye is about 25 kilometres wide here. With wind speeds reaching 260 kilometres per hour, the storm has already killed at least one person and left many without power or water. Further damage is expected. This is the earliest time in the year on record that a category 5 hurricane has developed in the Atlantic.

Analysis Obesity

Should weight-loss drugs be used by children? Major US healthcare organisations have offered contradictory advice about the use of these medications in adolescents with obesity. How much do we know about their effects, asks Grace Wade

AS THE number of weight-loss drugs on the market has increased, so has confusion about the appropriate time for doctors to suggest someone begins using them – especially when it comes to children. Now, conflicting advice offered by two major US healthcare organisations is muddying the water even more.

Last year, the American Academy of Pediatrics (AAP) shocked people by recommending the use of weight-loss medications in adolescents, or children aged 12 and up, in an effort to address soaring rates of childhood obesity. These drugs include semaglutide, which has already been approved by the US Food and Drug Administration (FDA) to treat adolescent obesity and is sold under the brand names Wegovy and Ozempic. The European Union, the UK and the United Arab Emirates have also approved semaglutide for adolescents.

But newly published guidelines from the US Preventive Services Task Force (USPSTF), an advisory panel composed of independent health experts, contradict this suggestion, finding there is insufficient evidence to make a recommendation on weight-loss drugs for adolescents.

Determining when or if it is safe and effective to use these drugs in young people is crucial. The global prevalence of childhood obesity has quadrupled since 1990, placing an ever-growing number of children at an increased risk of developing obesity-related conditions such as heart disease, type 2 diabetes and liver disease. It is a complex epidemic that will require complex solutions, and the conflicting guidance from the AAP and USPSTF underscores just how little we understand.

A clinical trial run from 2019 to 2022 in children aged 12 to 18 with obesity found that semaglutide decreases body mass index (BMI) by about 16 per cent on average. It was then approved in the US for those aged 12 and older with obesity.

ANDREAS PROTT/ALAMY

Semaglutide is an injectable weight-loss drug. Little is known about the effects of long-term use in children

"Once the FDA came out with these approvals – and several of [them] came as we were working on the process of writing the guidelines – we really had no hesitation about including [weight loss drugs] as part of the guidelines," says Sarah Barlow at the AAP.

She and her colleagues recommend doctors offer weight-loss medications to children with obesity starting at 12 years old, alongside behavioural interventions focused on diet and exercise.

"We really take a whole-child approach, and that means really understanding all of the ways we can help families. And as part of the toolbox, there is a time and place for obesity medications," says Barlow.

However, the USPSTF came to a different conclusion. It found insufficient evidence to make a recommendation on weight-loss drugs in adolescents, particularly when it comes to long-term effects (*JAMA*, doi.org/m56d). Only eight trials, totalling fewer than 1500 participants, have assessed these medications in adolescents, and each drug had just one trial lasting at least a year, according to the report.

"Teenagers are not just small adults. They're growing and developing," says Thomas Robinson at Stanford University in California. "What are the effects on the developing brain? On bone development and strength? There's a lot of open questions."

These weight-loss medications must be used indefinitely or there is a risk of regaining lost weight, so long-term studies are key. Wanda Nicholson at the USPSTF says the task force is calling for more research on all of these drugs with at least two or more years of follow-up in children.

Even in the absence of this data, Barlow believes it can be appropriate to treat adolescents with weight-loss drugs given the harmful effects of obesity. For instance, a 2019 analysis of more than 1.5 million children aged between 5 and 18 found those with obesity were 1.4 times as likely to have prediabetes, 4.4 times as likely to have high blood pressure and 26.1 times as likely to have liver disease as those of a healthy weight.

Whether weight-loss medications meaningfully lower these risks isn't clear, though. The USPSTF found just one medication, Qsymia, reduced blood pressure in children, while semaglutide was the only one to lead to small improvements in quality of life, such as physical comfort. No long-term evidence has shown that reducing BMI in childhood lowers the risk of chronic disease later in life, either.

"I think a lack of evidence doesn't mean that the evidence is against it," says Robinson.

The obesity epidemic has been growing for years, and it is understandable that people may be relieved to see the early signs of semaglutide's success at instigating weight loss. But without more data, we can't know if rushing to use this or other weight-loss drugs in children could be trading in one epidemic for another that we can't yet see. ▮

8
trials have assessed the effects of weight-loss drugs in children

<1500
children were included in these studies in total

DAN KENYON/GETTY IMAGES

Archaeology

Mysterious ancient culture revealed

Rock art in Venezuela offers a glimpse thousands of years back to a culture unknown to science

Becky Ferreira

AN ARCHAEOLOGIST has tracked down more than 20 rock art sites in south-eastern Venezuela decorated with evocative geometric designs that may date back several thousand years. The pictograms and petroglyphs offer a rare glimpse into the culture of people who lived in the forested highlands that now make up Canaima National Park, long before the arrival of Europeans.

José Miguel Pérez-Gómez at Simón Bolívar University in Caracas, Venezuela, has collaborated for years with the Indigenous Pemón community to document the art, which he says belongs to a cultural tradition that is unknown outside these communities. He unveiled pictures and early findings about the sites on 27 June at New Worlds New Ideas, a rock art conference in Valcamonica, Italy.

"We're facing something totally new, something unpublished, something that has never been studied," says Pérez-Gómez. "We're just starting, but it's very interesting because this is filling a gap in the region. Nobody ever thought Venezuela, in this part, had such a rich culture."

Angel Falls, the world's tallest uninterrupted waterfall, attracts tourists to Canaima, but most of the expansive park is isolated and accessible only on foot. By teaming up with the Pemón, Pérez-Gómez was able to locate art that had been painted on secluded cliffs or carved into rock above river rapids.

Pictograms found on rocks in Canaima National Park, Venezuela

UNIVERSIDAD SIMON BOLIVAR

The rock art hasn't been formally dated, but Pérez-Gómez estimates that it is between 4000 and 7000 years old based on comparisons with similar motifs that have been dated in neighbouring countries, including Brazil and Colombia. He is planning further expeditions to assess the art, including stratigraphic analysis and radiocarbon dating, which would help put a timeline on the images.

The depictions include shapes, lines, dots and patterns that look like nets, braids or mountaintops. The meaning of these abstract designs to the people who made them remains a mystery.

"For archaeologists, it's very difficult to get into the mind of people that lived 4000 years ago," says Pérez-Gómez. Still, he adds, "for these people, these places meant something. It helped them to explain their reality and their connection with the landscape. It was a portal for them to connect with the supernatural worlds, connecting, perhaps, to other people and their loved ones."

Andrés Troncoso at the University of Chile in Santiago says the rock art "fills a blank space and provides new data to better understand this region's pre-Hispanic history".

The Pemón people who helped him locate the art don't recognise it as part of their own culture, which has only been present in the region for about 500 years, says Pérez-Gómez. "The people that know about these places consider them taboo," he says. "For them, it was made for an evil spirit." ▮

See page 36 for more on lost South American cultures

Botany

Moss that survives extreme conditions could live on Mars

A HARDY moss found in desert locations around the globe can survive conditions that are lethal to almost all other life, suggesting it could be the first possible pioneer species for the colonisation of Mars.

Syntrichia caninervis **is widespread in some of Earth's harshest locations, including Tibet and Antarctica, so Xiaoshuang Li at the Xinjiang Institute of Ecology and Geography in Urumqi, China, and his colleagues decided to test just how much it could cope with.**

The researchers found that the moss could regenerate after being stored at -80°C for five years or in liquid nitrogen at -196°C for a month. They also bombarded it with gamma radiation and found that up to 500 Gray units (Gy) actually helped the moss regenerate, while only doses over 8000 Gy caused severe damage. Most plants can't cope with radiation above 500 Gy, while 50 Gy is enough to cause convulsions and death in humans.

The team then put the moss in simulated Martian conditions, including an atmosphere composed of 95 per cent carbon dioxide, temperatures that fluctuated from -60°C to 20°C, high levels of UV radiation and low atmospheric pressure. Even after a week in the simulator, the moss was able to fully regenerate after 30 days when returned to Earth-like conditions. (*The Innovation*, doi.org/m567).

"If there is one plant that is capable of living on Mars, it is that moss," says David Eldridge at the University of New South Wales in Sydney, Australia. Yet if the moss is to thrive, he adds, it will need some relief from cold and desiccation, which may not be possible on Mars.

"If there is one plant that is capable of living on Mars, it is that moss"

Sharon Robinson at the University of Wollongong, Australia, says it isn't clear why we would want to take the moss to Mars. "We can't eat them, although if they were photosynthesising they might be able to make a bit of oxygen," she says. Alternatively, the moss could be a home for tardigrades, an equally hardy species. ▮

James Woodford

Earth science

Water from 2022 Tonga eruption still in the atmosphere

James Dinneen

WHAT goes up doesn't actually always seem to come down. Most of the nearly 150 million tonnes of water vapour launched into the air by the underwater eruption of the Hunga Tonga-Hunga Ha'apai volcano in 2022 remains there, setting record concentrations in many parts of the atmosphere.

"It's really a very special, unprecedented event," says Christian von Savigny at the University of Greifswald in Germany.

The eruption increased the concentration of water vapour in the stratosphere – located between around 6 and 50 kilometres above Earth – by as much as 15 per cent, which has a slight warming effect. Unlike other eruptions, it didn't release much sulphur, which has a cooling effect. Previous research suggested this small warming effect would continue until 2035.

Gerald Nedoluha at the Naval Research Laboratory in Washington DC and his colleagues measured concentrations of water vapour in the stratosphere and the higher mesosphere in the time since the eruption using a microwave instrument aboard NASA's Aura satellite, as well as several ground-based instruments.

They found that, in November 2023, concentrations were still elevated in much of the atmosphere above 17 kilometres, indicating that most of the water vapour from the eruption remained aloft nearly two years later (*JGR Atmospheres*, doi.org/m564). Over that period, they found concentrations in much of the stratosphere and large parts of the mesosphere above it broke records extending back 20 years.

The ability to track the plume of water vapour in such detail will enable atmospheric scientists to gain insights into how such eruptions influence the climate, from the possible depletion of the ozone layer to cloud formation. ▮

Environment

Solar boom covers farmland that could feed millions

Madeleine Cuff

THE worldwide growth in solar energy has led to huge numbers of panels being installed on prime agricultural land, taking quadrillions of calories out of the global food supply.

Much of this increase has happened on cropland that could produce enough food to feed millions of people, say Wu Xiao at Zhejiang University, China, and his colleagues.

The researchers used satellite imagery to detect where solar panels had been installed around the world and calculated the food production impact. "Our research reveals an exponential increase of PV installations on cropland," says Xiao.

More than 5000 square kilometres of the world's surface was covered by solar photovoltaic (PV) panels by 2018, the latest year of data, an increase of 1655 times in just 15 years. Around 27 per cent of that was over cropland, totalling about 1370 square kilometres of land.

Solar panels are often built on land that could be used for farming

This was responsible for food production losses in 2018 in the region of 4 petacalories, an amount that could feed 4.3 million people for a year. In scientific terms, the "Calorie" used in common parlance, for example on some food labels, is actually 1000 calories, while a petacalorie is a million billion calories.

~27%
of solar installations by 2018 were on cropland

On current trends, the lost food production could climb to 62 petacalories a year by 2050. "If we continue to encroach on cropland of similar cost (food loss per solar energy gain) at the current rate, it will lead to a 16-fold increase in annual food production losses compared to 2018," says Xiao.

China, eastern North America and western Europe face some of the most intense conflicts between using cropland for food or energy production, the study found (Research Square, doi.org/m565).

However, Xiao says the work, which hasn't yet been peer reviewed, may have overestimated food production losses because it assumed there would be no crops or pasture below solar panels. Grazing sheep in fields with solar panels, for example, has been shown to be effective.

Losses will continue to climb as solar panels encroach on fields, unless policy-makers take action, says Xiao. "I think the biggest concern is sound planning, choosing the right place for the right land use," he says. "What we are looking for is a win-win situation between energy demands and food security."

Productivity improvements in agriculture could compensate for the loss that comes from growth in solar, says Eric Larson at Princeton University.

Improvements in solar technology could also cut the amount of land needed for this type of energy generation, says Max Zhang at Cornell University in New York. "I'm hoping we will still see more efficient panels being adopted and better designed solar farms that use land more efficiently," he says.

Some see demand for solar energy as an impetus for change in the farming industry. Arable grower Martin Lines, of the UK's Nature Friendly Farming Network, says agricultural land could be used more efficiently. "The reality is that 62 per cent of the grain that we produce in the UK feeds livestock," he says. In the future, we might see farmers as producers of energy as well as food, he says. "We need to rethink the role of the farmer." ▮

COSTFOTO/NURPHOTO/SHUTTERSTOCK

Infectious diseases

Dangerous mpox strain spreading

New form of the virus has emerged in a mining town in the Democratic Republic of the Congo

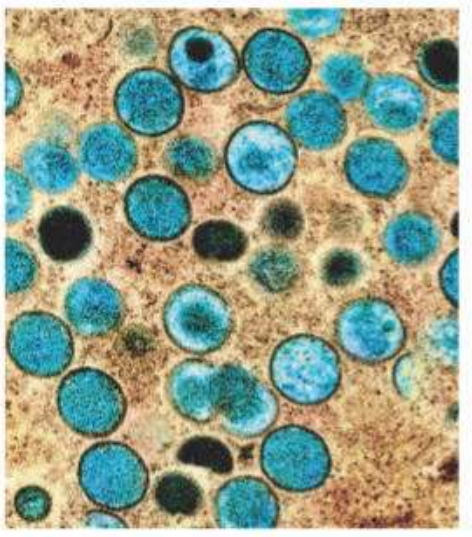
Michael Le Page

URGENT action is needed to try to contain the spread of a new strain of mpox that has caused more than 1000 cases in the Democratic Republic of the Congo, say health experts dealing with the outbreak. They fear it may spread to neighbouring countries and possibly further afield.

"It's undoubtedly the most dangerous so far of all the known strains of mpox," says John Claude Udahemuka at the University of Rwanda.

The new form of the virus, which has been transmitted mainly by heterosexual sex, was first identified in the mining town of Kamituga in South Kivu province in the east of the DRC in September. In recent weeks it has spread to cities in the area, and may already have reached neighbouring countries such as Rwanda, Burundi and Uganda, says Leandre Murhula Masirika at the South Kivu health department.

Last week, the city of Goma, which is on the border with Rwanda, confirmed its first cases, says Masirika.



NIAID

Electron microscopy image of mpox virus particles (teal) within an infected cell

The experts hope a vaccination campaign can halt the spread of the new strain. However, it isn't yet known whether any existing vaccine will work against it, says Udahemuka. "We hope it will."

For decades, there have been occasional outbreaks of mpox – formerly known as monkeypox – in central Africa caused by clade 1 mpox, which circulates in non-human animals and can infect people who handle bushmeat.

In September 2023, health workers in Kamituga noticed cases that appeared to be spread via sex, as well as other close contact. It also caused more serious, longer-lasting symptoms, and with many cases among children. "They are seeing horrendous whole body rashes," says Trudie Lang at the University of Oxford.

The sexual transmission suggested the cases might be due to the clade 2 mpox strain that spread to many countries around the world in 2022.

Yet when Udahemuka and his colleagues sequenced the genome of samples from Kamituga, they discovered the cases were caused by a mutated strain of clade 1, now known as clade 1B.

"It's incredibly worrying," says Lang. There is high transmission between mothers and other carers and children, and also non-sexual person-to-person transmission outside of households, she says.

The mortality rate of clade 1B is around 5 per cent in adults and 10 per cent in children, says Lang. The virus can also cause miscarriages and stillbirths.

"It's undoubtedly the most dangerous so far of all the known strains of mpox"

"The cases are still going higher and higher every day," says Masirika, who thinks it is only a matter of time before the new strain spreads even further.

Other countries should prepare for the potential arrival of the virus, says Udahemuka. They should also support the local health response in the region so it doesn't spread, he says. ▮

Zoology

Ants amputate each other's limbs to save them from infection

SOME ants chomp off the infected limbs of nestmates to boost their chances of survival, making them the only recorded non-human animals to perform amputations to save another's life.

Ants are one of the few animals that tend to the injuries of their peers. Matabele ants (*Megaponera analis*), for example, can treat infections by secreting an antimicrobial substance. But not all ant species have the glands to do this, says Erik Frank at the University of Würzburg in Germany. "We wanted to find out what happens with ants that cannot use antibiotics."

While observing colonies of Florida carpenter ants (*Camponotus floridanus*) in the lab, Frank and his colleagues spotted several instances of ants chewing off a nestmate's wounded leg.

Each time, the amputee showed no signs of struggle. What's more, the amputations only took place when the injury was on an individual's upper leg.

To learn more, the team gave thigh injuries and infections to 72 carpenter ants. Half of the ants received leg amputations from the researchers, while the others were left as a control. The mortality rate of amputees was 90 per cent lower than in the control group, which suggests these procedures stopped the pathogen from spreading.

PAUL YOUNG/ALAMY

Florida carpenter ants (*Camponotus floridanus*) know when to do surgery

In contrast, amputations by other ants never occurred if a wound was on an ant's lower leg, and when the team repeated the experiment with lower-leg injuries, the mortality rate was the same for both the amputees and the control group (*Current Biology*, DOI: 10.1016/j.cub.2024.06.021). This could be down to ant physiology, says Frank. "Insects don't have a central heart like we do," he says. Instead, several muscles pump blood around the body, and by using micro-CT scans, the team found that many of these muscles are concentrated in the upper legs of carpenter ants.

That means upper-leg amputations damage blood-pumping muscles, preventing blood from circulating and spreading infections. And since the lower legs lack these muscles, amputating them doesn't stop the spread. ▮

Chen Ly

Space

Why time ticks faster on the moon

NASA is working to define a time zone for the moon as an aid to lunar exploration

Jonathan O'Callaghan

ASTRONAUTS, set your watches. Time on the surface of the moon has been calculated to tick at a rate of 57 millionths of a second a day faster than it does on Earth, a difference that could be crucial as lunar exploration ramps up.

Later this decade, NASA hopes to return humans to the moon for the first time in more than 50 years, while in the past two years, six uncrewed spacecraft have attempted lunar landings.

"We're looking at a sustained presence on the moon," says Cheryl Gramling at NASA's Goddard Space Flight Center in Maryland. "Infrastructure on Earth such as GPS provides time down to the nanosecond level. If you're trying to navigate or land on the moon, and avoid dangerous areas, then that precision matters."

To tackle this issue, NASA was recently tasked by the White House to create a Coordinated Lunar Time for the moon by the end of 2026. Slava Turyshev at NASA's Jet Propulsion Laboratory in California and his colleagues were already working on the problem, and now have an answer. "Somebody needed to sit down and work out the maths," he says.

"If you're trying to navigate or land on the moon, and avoid dangerous areas, then precision matters"

Time ticks faster on the moon because its gravity is one-sixth that of Earth's, a result of time dilation, as postulated by Albert Einstein's theory of general relativity.

Turyshev and his team have calculated the flow of time on Earth and the moon in reference to the centre of the solar system, known as its barycentre, which moves depending on the position of the planets relative to the sun. Their calculations show that time on the moon's surface ticks 57.5 microseconds per Earth day (0.0000575 seconds) faster than it does on Earth's surface, so over 50 years, an astronaut on the moon would be about a second older than if they had stayed on Earth (arXiv, doi.org/m59g).

"This approach may now be used to synchronise all the assets on the moon," says Turyshev.

Previous results for calculating lunar time have arrived at a similar number. In February, a study calculated that time on the moon's surface ticked 56 microseconds faster than on Earth, based on the orbits of the two bodies. Having multiple results will help create an accurate time zone, says Gramling. "The mathematics behind this will have to be synthesised together to make sure all the equations match up," she says, noting it is likely that the moon will have just a single time zone at first.

A definition of lunar time will come from a number of bodies, including the International Bureau of Weights and Measures and the International Astronomical Union, with some discussions set to take place in August. It will be up to individual countries also interested in lunar exploration, such as China, whether they decide to follow this recommendation, though.

Defining moon time will also require us to set a "zero day" date on which we begin tracking lunar seconds compared with Earth, in the same way that international atomic time, as measured by atomic clocks, was agreed to begin on Earth on 1 January 1977. ▮

Health

Baby-led weaning is as good nutritionally as spoon feeding

BABIES who hand-feed themselves solid food seem to consume the same number of calories as those given puréed food from a spoon, suggesting that such "baby-led weaning" offers no particular nutritional benefits or drawbacks.

Despite the popularity of baby-led weaning, in which babies choose what to eat, there is little scientific understanding about it, says Kinzie Matzeller at the University of Colorado. To learn more, she and her colleagues asked the parents of 100 healthy, 5-month-old babies living in the Denver, Colorado, area to report their babies' food and milk intake for three days, as well as weighing the food on their plate before and after meals so they could determine how much the baby had consumed.

The parents provided these food intake reports again when the babies were 9 months and 12 months old. Matzeller's team weighed and measured the babies at each of these points.

Using the diet records, the researchers identified 35 infants who were on a baby-led weaning system, which they defined as one in which puréed food provided less than 10 per cent of their total calories. The team then selected 35 conventionally fed babies that matched those in the baby-led weaning group in terms of ethnicity, sex and whether they were breastfed or given formula.

Matzeller told the American Society for Nutrition meeting in Chicago, Illinois, on 30 June that there were no significant differences in daily energy intake – the number of calories consumed per kilogram of body weight – between the groups at any point. The baby-led weaning infants were consuming about 22 per cent more protein than the other babies at the 9-month mark, but this evened out by 12 months.

YAORUSHENG/GETTY IMAGES

Infants feed themselves in baby-led weaning, which can be a messy business

At 9 months and 12 months, the baby-led weaning infants had gained more weight with respect to their age and their height, although the differences were minor.

"If you gave me two growth charts of a baby-weaned versus conventionally weaned infant, I probably wouldn't be able to tell you which one is which," says Matzeller.

Baby-led weaning was, however, more common among mothers who had gone to college and had higher annual family incomes, possibly because they can afford the time and expense that baby-fed weaning often requires, says Matzeller. ▮

Christa Lesté-Lasserre

Technology

AI can predict how monkeys play *Pac-Man*

Chris Stokel-Walker

AN ARTIFICIAL intelligence can accurately predict how a monkey plays the video game *Pac-Man* and mimic the animal's eye movements.

Tianming Yang at the Chinese Academy of Sciences and his colleagues trained two rhesus monkeys to play *Pac-Man* by rewarding them with juice for collecting all the dots in a maze and evading capture by ghosts. Getting Pac-Man, the character players control, to eat the ghosts after chomping on a special dot that makes them vulnerable earned the monkeys a reward. As the monkeys played the game 35 times, their eye movements were tracked.

Then the researchers trained a type of brain-like AI known as a neural network to predict the monkeys' directional choices at maze junctions. The type of neural network they used, called a transformer network, has a self-attention mechanism that allows it to prioritise the most relevant information it encounters and act on it. Wang wondered if this attention mechanism would echo what was going on in a brain.

The AI's attention mechanism seemed to mimic what the monkeys were looking at, including focusing on where to move next, several moves in the distance – suggesting some element of the AI model was pre-planning its strategy.

The AI model was able to predict the monkey's choice of next move when Pac-Man reached a junction in the maze 87.6 per cent of the time (arXiv, doi.org/m57g). "We showed that, indeed, this transformer structure may do something similar to the brain," says Yang.

While it can be risky to anthropomorphise AIs, the research does indicate that they might be able to "think" or "look" in a similar way to mammals, says Noah Giansiracusa at Bentley University in Massachusetts. ▮

Analysis Nuclear fusion

Is the world's biggest nuclear fusion experiment dead?

The giant ITER project has been delayed by 10 more years. **Matthew Sparkes** looks at whether it is still worth pursuing

ITER ORGANIZATION/EJF RICHE

France plays host to the vast ITER fusion site

ITER, the world's largest fusion power project, has been hit by a 10-year delay, meaning plans to switch it on have now been pushed back to 2035. This could see the state-funded effort overtaken by commercial projects, leaving some questioning whether it is worth continuing with the experiment. Is it time to shut ITER down?

The reactor, which is being built in France, is a vast international effort chiefly involving the European Union, China, India, Japan, South Korea, Russia and the US. Work officially started in 2006, and the first run of the reactor to create the super-hot form of matter known as plasma, where nuclear fusion can occur, was initially scheduled for 2020, but was later pushed back to 2025. Construction costs have boomed: the estimate stood at €20 billion in 2020, more than triple that of initial projections.

Now, ITER's management has revealed that the first plasma run won't occur until 2035, a delay of another 10 years. As *New Scientist* went to press, the details behind this decision and future plans were due to be announced at a press conference on 3 July.

Juan Matthews at the University of Manchester, UK, says ITER now feels like "the elephant in the room" in fusion circles. He believes that advances in containment technology made since ITER was designed may lead to cheaper and smaller reactors, often being developed by small commercial teams. These could offer a promising path to fusion power without the vast scale previously thought necessary.

2035

New date when ITER project would first produce plasma

"If I was an economist, I would say 'don't chase sunk costs'," says Matthews. "There's no reason why the people and the skills that are on the ITER site can't be used to make something else."

One of those promising new reactors is being constructed by UK start-up Tokamak Energy. But there are dozens of similar companies working on various designs around the world.

David Kingham at Tokamak Energy says he welcomes ITER's willingness to share information. "ITER has validated the performance of many important materials and stimulated the development of supply chains for materials and other enabling technologies," he says.

Laban Coblentz, head of communications at ITER, told *New Scientist* that the project has been forced to pivot from its original strategy. The initial plan for ITER called for replacement parts that could be fitted once the machine had started operating, allowing it to push to higher energy levels.

Due to delays, those replacement parts are ready before operations begin. Bringing their use forward could shorten the ramp-up to higher energy levels once the reactor fires up, but fitting them would delay when the first plasma is produced.

ITER has taken the decision to do that rather than push ahead with experiments that have a lower reward, says Coblentz. For instance, ITER was initially due to run with 100 kiloamperes of magnet current, but will now ramp up quickly to 15 megamperes – 150 times more.

The result is that ITER will no longer be a project that represents the global pinnacle of fusion research. Instead, it will be a learning facility, says Coblentz. The old way of thinking is that you build the public facilities, you answer scientific questions and then the private sector takes over, he says. "But what we're seeing is an acceleration in the knowledge transfer. The private sector, none of them want us to stop or shut down our facility. In fact, what they're saying is 'for God's sake, keep going, go as fast as you can'." ▮

Archaeology

A Neanderthal with Down's syndrome

A fossil bone displaying features of Down's syndrome came from a Neanderthal child, adding to evidence that these extinct humans cared for members of their community, finds **Michael Marshall**

A NEANDERTHAL child who survived until at least the age of 6 may have had Down's syndrome, an analysis of a fossilised bone suggests. The find adds to the evidence that Neanderthals, far from being brutish and unfeeling, routinely showed compassion for other members of their society. However, researchers disagree on the extent to which the child may have needed extra attention.

"Neanderthals were clearly caring for people in their group and this is a lovely example that really brings home how much they cared," says Penny Spikins at the University of York in the UK, who wasn't involved in the work.

The fossil was found in Cova Negra, a cave in eastern Spain. Previous excavations have revealed that it was home to Neanderthals between 273,000 and 146,000 years ago.

Sorting through animal remains from the cave, researchers led by Mercedes Conde Valverde at the University of Alcalá in Spain identified a fragment of hominin bone. It was found in disturbed sediments, so can't be reliably dated. The fossil is part of the temporal bone from the side and base of the skull, and includes parts of the inner ear.

Conde Valverde and her colleagues used CT scans to create a 3D model of the bone. This enabled them to identify it as being from a Neanderthal, not a modern human. Based on its developmental state, the bone belonged to a child who was at least 6, and probably no more than 10.

The team found several distinctive features in the inner ear, specifically in three tubes called the semicircular canals that are involved in hearing and balance. One canal was unusually wide. Another was connected to a neighbouring chamber called the vestibular aqueduct, which is normally separate. Furthermore, the cochlea, which is crucial for hearing, was especially small (*Science Advances*, doi.org/m5tj).

Bone detectives

This combination of features is found only in people with Down's syndrome, says Conde Valverde. In this genetic condition, instead of having two copies of chromosome 21, a person generally has three. The condition can cause learning disabilities, problems with hearing and balance, and distinctive facial features.

It has probably existed as long as humans: a study of ancient DNA, published in February, found six cases of Down's syndrome in babies and young children, one dating back almost 5000 years.

The newly identified child would probably have needed more care than other Neanderthal children, says Conde Valverde. For instance, moving from place to place may have been difficult due to attacks of vertigo, which can be a symptom in Down's syndrome.

"This is a lovely example that really brings home how much Neanderthals cared"

"We think that probably the mother needs help," she says, because the time demands of increased childcare would take her and potentially the father away from activities like obtaining food.

Conde Valverde says the other Neanderthals in the group are unlikely to have expected the child to contribute much practical help, so they must have cared for them out of pure compassion.

Sarah Turner at Concordia University in Montreal, Canada, doesn't think this low expectation is necessarily true. "People with Down's syndrome contribute in all sorts of ways to modern human societies," she says. "And I am sure that was true in Neanderthal society too."

"There is a lot of variation in terms of what is considered a disability and how people with disabilities are treated in different human contexts," says Turner. "Compassion is one possible motivator, but without knowing about someone's life and how they were treated and behaved, I don't think we can say too much about how and why they survived."

Turner has also shown that wild primates can survive for a long time even if born with disabilities or developmental conditions. This included one infant chimpanzee born with what appeared to be Down's syndrome that survived as long as the mother had help from an older daughter, but died after the daughter had a baby.

The new study adds to the evidence of compassion in Neanderthals, says Spikins. For instance, a Neanderthal man whose remains were found in Shanidar cave in Iraq had a paralysed arm, a badly damaged leg and was "probably deaf and blind in one eye". He lived 10 to 15 years after getting these injuries, so "must have been looked after".

Conde Valverde and Spikins both dismiss the idea that caregiving would have been done in the expectation of getting help once a child had grown up.

"It comes very much from our society, this idea of analytically thinking if someone's going to be productive," says Spikins. The reality is that we evolved to live in tight-knit groups and an instinct to care for each other was crucial. People with Down's syndrome are often "tremendously affectionate and very sociable", she says, "and that counts for such a lot in these kind of small-scale societies". ▮

Right: Cova Negra, a cave in eastern Spain where a fossil of a Neanderthal child's distinctively developed temporal bone (below) was found

L: JULIA DIEZ-VALERO; R: JLPORTI CC BY SA 4.0

Technology

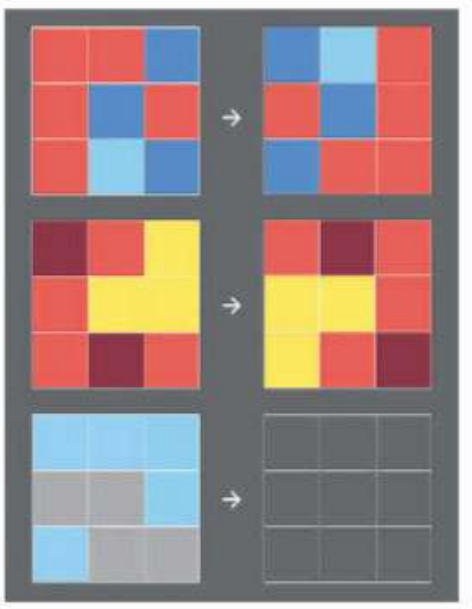
$1m prize for AI that can solve puzzles that are simple for humans

Alex Wilkins

A SET of puzzles that will challenge even today's most sophisticated artificial intelligence models, while being relatively easy for people, aims to encourage AI developers to create new techniques. Any AI that solves the puzzles will net its creators a share of a $1 million prize fund.

Companies such as OpenAI already claim that AI models like GPT-4 exhibit "human-level performance" on real-world tests, such as the bar exam for lawyers. But this isn't because the models are reasoning like humans, says Mike Knoop at software company Zapier, but because they have effectively memorised the answers from the vast amount of internet data they have been trained on. "They can't generalise to new novel situations," he says.

Knoop and François Chollet at Google have now announced a $1 million prize fund for any AI that can perform at a human-level or better at the Abstraction and Reasoning Corpus (ARC), a test designed by Chollet in 2019 to be resistant to the memorisation that AIs are good at and to require the sort of general, basic intelligence that is natural to humans.



MIKE KNOOP

Can you work out the pattern of the final square?

The test consists of paired grids of pixelated shapes linked by a pattern, such as moving the pixels of an object in a consistent way. To correctly answer a question, you have to find the pattern by studying example pairs and then use that information to complete the second half of a new pair (see the image, left).

This requires only a small set of reasoning capabilities, says Knoop, such as object permanence, goal-directedness, counting and basic geometry. These skills are something even young children display but are often lacking in large language models (LLMs) such as GPT-4.

If someone wins the $500,000 grand prize, which requires achieving a score of 85 per cent, or 1 percentage point more than the average human, then they will have designed an AI system that is much more capable than today's models, says Knoop.

Researchers hoping to design an AI capable of beating the test can practise on a public dataset, but to win the prize they will have to beat an offline ARC test, which is kept private to prevent LLMs memorising the answers.

"It is testing something very important, which is the ability of systems to deal with novelty," says Thomas Dietterich at Oregon State University.

However, it isn't clear whether there might be ways to solve ARC challenges that don't require the capabilities that Knoop and Chollet hope to test for, says Dietterich, such as finding a way to generate all the possible instances of the ARC problems through computational brute force and memorising the answers.

Knoop acknowledges this is a risk, but says that one of the rules is that the tasks must be solved "efficiently", which means teams get just 12 hours and a limited amount of computing power to solve the private dataset. ▮

Puzzle answer: The pattern is rotated by 180 degrees.

Palaeontology

Trilobites preserved in incredible detail by volcanic eruption

ARNAUD MAZURIER/UNIVERSITY OF POITIERS

This reconstruction reveals features such as the digestive system (blue) and the harpoon-like hypostome (green, far left) near the mouth

A FOSSIL site in Morocco has been called the "Pompeii of trilobites" because it contains sublimely detailed fossilised moulds of the creatures, preserved by a pyroclastic ash flow from a volcanic eruption some 509 million years ago.

"They are absolutely, no question, the best-preserved trilobites ever found," says John Paterson at the University of New England in Armidale, Australia. It is much like how an eruption preserved the Roman city of Pompeii.

Trilobites are marine arthropods that existed from about 520 million years ago until nearly 252 million years ago. We know of more than 22,000 species, and countless fossils have been discovered, but these are normally just their tough exoskeleton. The creatures' soft parts are rarely found and have always been damaged.

However, the trilobite fossils collected in 2022 from south-west of Marrakesh, Morocco, are something special, says Paterson. "On one of the more complete specimens, all of the appendages are preserved in 3D, right down to the bristles on their walking legs."

So far, Paterson and his colleagues have collected four specimens, each only around a centimetre long.

The team scanned the moulds with a micro CT scanner and was able to create perfect 3D images of the creatures (*Science*, doi.org/m5tm). The scans have allowed the team to resolve some important details of trilobite anatomy that have been long debated, such as the structure of its feeding apparatus.

Another insight was how the creatures used their spiny legs as a shredding tool. "They chewed with their legs and pushed the food from their legs up to their mouth," says Paterson. ▮

James Woodford

Space

Odd galaxies break cosmic theories

Strange early galaxies seem to have far too many stars or impossibly huge black holes

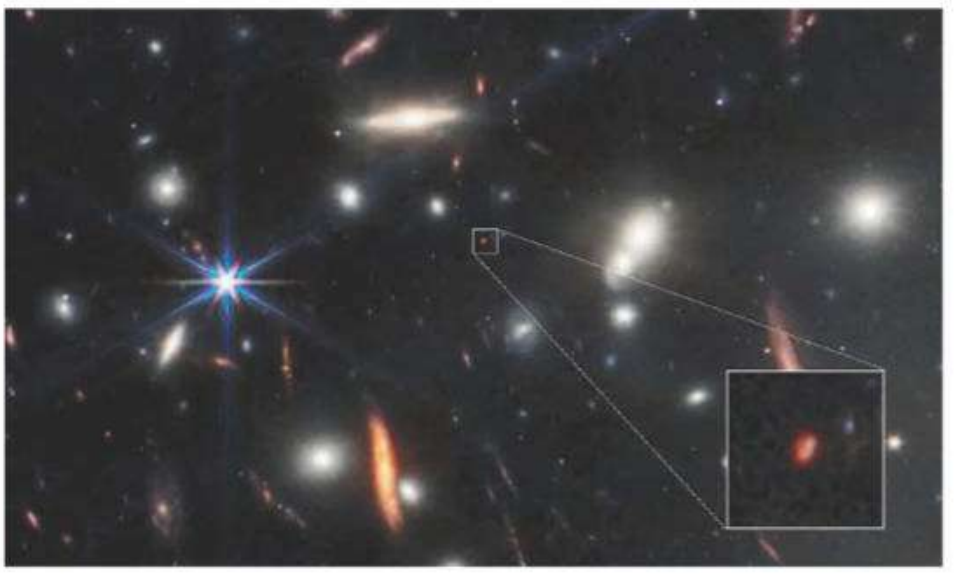
Leah Crane

THE "little red dots" discovered by the James Webb Space Telescope (JWST) pose a cosmic conundrum. It seems that these compact galaxies are either stuffed impossibly full of stars or have black holes that are far too large. Either way, they present problems for our views of galactic evolution.

When JWST started peering into the early universe, it saw hundreds of tiny red galaxies everywhere it looked. Their existence alone was surprising, but digging into the data reveals that the properties of these galaxies, called little red dots, don't make sense.

"There are a lot of these little red dots, and some of them are so bright, so very luminous, that they kind of defy what we expect," says Hollis Akins at the University of Texas at Austin. He and his colleagues tested two possible sources of the light from these galaxies: starlight and the light from material falling into supermassive black holes at the galaxies' centres.

They found that both potential solutions cause problems. If the light is dominated by stars, then little red dots must be churning out so many stars at such high rates that they should, in theory, give the modern universe much more mass than it has. If the light is dominated by black holes, those black holes are far larger than we would expect to be possible, given the size of their host galaxies (arXiv, doi.org/m5nv).



NASA, ESA, CSA, AND STSCI

One of the "little red dot" galaxies with unexplained properties

"Maybe it's a mix of both – but even if you assume that half of the light is coming from supermassive black holes and half is coming from stars, you still get a problem because the sources are just everywhere," says Caitlin Casey at the University of Texas at Austin. "It's a real conundrum."

In fact, Fabio Pacucci at the Harvard-Smithsonian Center for Astrophysics in Massachusetts and his colleagues found that even if only 1 per cent of the light from these galaxies comes from black holes, they are still 10 to 100 times too big for their galaxies, based on what we know about the nearby universe (arXiv, doi.org/m5nt). This could be an indication that supermassive black holes formed extraordinarily quickly in the early universe – that is the only way they could have gotten so large.

"It's the typical chicken or egg question: if the galaxy formed first and the black hole then collapsed at the centre, or if the black hole formed first and then the galaxy assembled around it," says Pacucci. The extreme masses of these black holes are the strongest evidence yet for the latter situation, he says.

"None of the pieces fit nicely using the common models of galaxies and black holes, meaning that we are probably missing something fundamental," says Bingjie Wang at Pennsylvania State University. "But no one has put forward a compelling new theory yet."

Little red dots have other odd properties, such as the old ages of their stars and dimness in X-ray wavelengths, that also need explanation. JWST should make more observations of little red dots in coming years, and those may help us put the pieces together. ▮

Archaeology

Ancient scribes had terrible posture while working

EGYPTIAN scribes who put brush to papyrus thousands of years ago are often depicted as kneeling or sitting cross-legged – postures that seem to have taken a toll on their bones.

The skeletons of 30 such scribes show more degenerative changes than 39 other adult male Egyptians from the same era. All the bodies were buried in a necropolis among the pyramids at Abusir, Egypt, between 2700 and 2180 BCE.

Beyond signs of stress in their spines, shoulders, knees, hips and ankles, the scribes' skeletons also have degenerated jaw joints – possibly from repeatedly chewing rush stems to form brush heads for writing. "Today, someone would probably advise them not to write with their head down and chew that rush pen," says Petra Brukner Havelková at the National Museum in Prague in the Czech Republic.

She and her colleagues examined the physical remains and analysed the presence or absence of more than 1700 different features on each skeleton, such as changes on the surfaces or edges of joints that may indicate osteoarthritis (*Scientific Reports*, doi.org/m5pw).

The team considered possible causes for such skeletal changes by looking at statues or wall decorations from the Old Kingdom period of Egypt, which depict scribes in various sitting or standing positions, says Veronika Dulíková at the Czech Institute of Egyptology.

Skeletal changes in the knees, hips and ankles seem the most likely to be associated with scribal work, says Sonia Zakrzewski at the University of Southampton in the UK. She praised the study for linking the skeletal analysis with archaeological evidence portraying specific body postures.

"Today, we would probably advise scribes not to write with their head down and chew that rush pen"

While modern office workers have ergonomic chairs and standing desks, skeletal changes can still occur. "The key thing to realise is that repetitive activity, especially if started from a young age, will have an effect on bone morphology," says Zakrzewski. ▮

Jeremy Hsu

Materials

Physicists reveal the paper most likely to give you a paper cut

Karmela Padavic-Callaghan

THE most dangerous type of paper is 65 millionths of a metre thick – at least when it comes to paper cuts.

"I got many paper cuts and frankly they were starting to annoy me," says Kaare Jensen at the Technical University of Denmark. After failing to find the cause in existing scientific studies, which he says mostly focus on the risk of infection, he and his colleagues decided to set up their own experiment.

They gathered several types of paper of different thicknesses, including tissue paper, print magazines, office paper, book pages, business cards and printed photos. They tested each paper's ability to cut a human finger by running it against a slab of ballistics gelatine, which is known to accurately mimic skin. The researchers created a small robot that pushed different paper samples onto the gelatine at various angles of attack.

Video recordings of these papery blows revealed the most hazardous situation: paper that is about 65 micrometres thick approaching the gelatine slab at a 15-degree angle. Such sheets are used for dot matrix printers as well as printed scientific journals. The research will be published in *Physical Review E*.

Jensen says that what earns this type of paper its cutting edge status is that it isn't so thin that it can buckle and radically deform when in contact with the gelatine – or a hand. At the same time, it isn't so thick that its impact would be blunted due to pressure being distributed across the paper.

The findings inspired the researchers to create a recyclable knife with a blade made from scrap paper, which was most effective when 65 micrometres thick. Their "Papermachete" could cut apples, cucumbers and even chicken – as long as it didn't get too wet. ▮

Palaeontology

The last woolly mammoths on Earth didn't die from inbreeding

James Woodford

ABOUT 10,000 years ago, a handful of woolly mammoths found themselves stranded on an island in the Russian Arctic, off the Siberian coastline. In the following millennia, this herd, of perhaps as few as eight individuals, grew to a stable population of between 200 and 300 animals before becoming extinct some 4000 years ago. They were the last known population of woolly mammoths – and if it weren't for bad luck, they might have survived into the modern era.

We now know the story of these mammoths thanks to a genetic study conducted by Love Dalén at Stockholm University in Sweden and his colleagues. They examined the DNA of 14 mammoths from Wrangel Island, plus seven from the mainland population prior to the small group being isolated by rising sea levels due to melting ice sheets – altogether covering 50,000 years of genetic history.

The analysis shows that, despite the small number of animals, inbreeding wasn't the reason for the mammoths' demise. Dalén says the population was purging major harmful genetic mutations, even though minor ones were accumulating.

"We can show that, in all likelihood, inbreeding and genetic diseases did not cause the population to gradually decline towards extinction," he says. "The population was doing OK despite the inbreeding."

~4000

years ago, woolly mammoths became extinct

However, the team found that individual mammoths were affected by genetic diseases, and this lower-level impact kept going for thousands of years (*Cell*, doi.org/m5sr). "This means that endangered species today, who in most cases were bottlenecked very recently, are likely to continue suffering from genetic diseases for hundreds of generations into the future," says Dalén.

He points to the Tasmanian devil as another example of a species that has become isolated on a large island after the mainland population went extinct and that is now suffering from low genetic diversity. This, in turn, affects the immune system, says Dalén. When its activity is reduced, a population is more susceptible to decline when facing a new pathogen, such as the facial tumour disease that affects the devils.

"It seems that natural selection was effective in removing potentially lethal mutations, but other, less severe ones gradually mounted," says Adrian Lister at the Natural History Museum in London.

"Whether this contributed to eventual extinction is uncertain, but it could have done, perhaps in combination with environmental change," says Lister. "There are lessons here for monitoring the genetic health of endangered species today."

Exactly what drove the mammoths to extinction is unclear, but intriguingly, the availability of freshwater lakes and rivers on Wrangel suggests they potentially could have survived for longer than they did, unlike a similarly isolated group that went extinct 5600 years ago due to drought.

"All these things like diseases, short-term climate events, tundra fires, are things we consider random events," says Dalén. "And since they are random, there was nothing inevitable about them happening and therefore had they not happened, maybe mammoths would have survived on Wrangel until today, assuming humans didn't kill them off when they finally arrived." ▮

Artist's impression of a woolly mammoth on Wrangel Island, Russia

BETH ZAIKEN

Medical technology

Safely targeting the deep brain

A non-invasive ultrasound device can precisely stimulate hard-to-reach brain structures, which could help treat depression, long-term pain and post-traumatic stress disorder, says **Michael Le Page**

A LOW-POWER ultrasound system can alter activity deep within the brain with far greater precision than previously possible, allowing the organ to be studied in new ways. It will also help brain surgeons plan operations and could be used to treat some conditions directly.

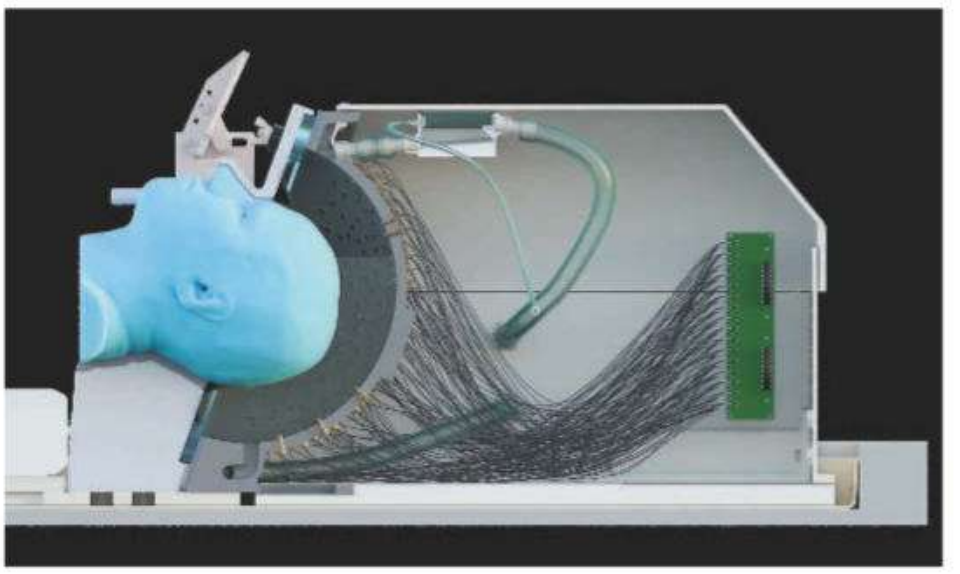
"I think it does open a new avenue for neuroscience," says Charlotte Stagg at the University of Oxford, whose team created the system. "We can, for the first time, transiently, safely, non-invasively modulate activity in various bits of the deep brain and see what happens in healthy adults."

Existing non-invasive ways of altering brain activity all have major limitations. One method is transcranial magnetic stimulation (TMS), which uses magnets to induce electrical currents in the brain. TMS is approved in the US for treating conditions such as depression, but it can only penetrate a few centimetres inside the skull and can't be focused on a small part of the brain.

"You need to stimulate each brain structure individually and this is the first kit that can do that"

Another approach, called transcranial electric stimulation, relies on electrodes placed directly on the head. Like TMS, it only affects the outer part of the brain and can't be precisely targeted.

Ultrasound, by contrast, can penetrate more deeply into the brain and can be focused. High-intensity ultrasound has been used since the 1950s to kill parts of the brain by heating them, for treating tumours, for instance. However, the systems for focusing it are attached directly to the skull with screws, so this technique still involves some surgery.



ELEANOR MARTIN ET AL.

A water-filled helmet carries 256 ultrasound sources to target small areas of the brain

In 2008, a team discovered that low-intensity ultrasound can stimulate or inhibit neural activity without causing any heating or damage. The mechanism still isn't fully understood, but it is thought to be a result of ultrasound affecting the ion channels in the membranes of neurons that help conduct nerve signals.

There is now a lot of interest in using low-intensity transcranial ultrasound for treating conditions such as depression, long-term pain and post-traumatic stress disorder, with several trials under way. Although low-intensity ultrasound can be focused, most systems aren't very precise because the field is still new.

Before now, the most sophisticated system was one developed by Tom Riis at the University of Utah and his colleagues. It consists of 252 ultrasound sources arranged in two arrays on either side of the head and it can focus on a volume of roughly 90 cubic millimetres.

The system developed by Stagg's team can focus on just 3 cubic millimetres. That is 30 times more precise than the set-up created by Riis's team and thousands of times more precise than most other systems, says team member Bradley Treeby at University College London.

This matters because some structures in the brain are millimetres in size. "They're very closely packed, and they do different things, and they often do opposing things," says Stagg. "You need to be able to stimulate each individually and this is the first kit we can do that with."

To achieve this focus, the team first scans the head of the person who will undergo ultrasound.

ELEANOR MARTIN ET AL.

The ultrasound system can be used with an MRI scanner

These scans are used to tailor a plastic face mask to immobilise the head in a precise position. The mask is attached to a helmet carrying 256 ultrasound sources that is sealed around the person's head and filled with water. The scans are also fed into a computer model that takes account of the skull's shape to work out how to focus the sound waves.

"We put a lot of effort into designing tools so that we can position our focal spot at exactly the location that we want," says Treeby.

Remarkable resolution

The system is also designed to be used inside an MRI scanner. In experiments on seven volunteers, the team used the scanner to confirm that the system could precisely target parts of a brain region called the lateral geniculate nucleus, involved in vision.

"The spatial resolution and the prolonged modulatory effects are remarkable," says Jean-François Aubry at Physics for Medicine Paris in France. "I think transcranial ultrasound stimulation is a very promising technology."

"It is the sharpest focusing I have seen," says Riis, who says the system will be transformative for research.

However, it is sometimes necessary to target a larger volume for treatments, say Riis, whose team is carrying out several trials. "In many applications, you would not want a focus this small."

A disadvantage of the system is that it requires the head of the scanned person to be shaved. This is because hair traps air bubbles that deflect ultrasound. Stagg says the team is trying to find a way of eliminating the bubbles, such as via a special shampoo. "It's probably solvable." ▮

Technology

AI learns to identify chess moves that are the most brilliant and entertaining

Matthew Sparkes

AN ARTIFICIAL intelligence can spot entertaining chess moves rather than just winning ones. This could lead to AIs that are more fun to watch or play against, and even offer insights into how we appreciate the game.

AI has long been able to beat even the most skilful human players at chess, with IBM's Deep Blue famously defeating world champion Garry Kasparov almost 30 years ago. But AI tends to analyse the game and make the move that is most likely to win, with no consideration for entertaining spectators.

Now, Kamron Zaidi and Michael Guerzhoy at the University of Toronto in Canada have developed a test to identify "brilliant" moves. This is a term in chess when someone plays an unexpected, creative or bold move that ultimately proves advantageous, and is marked in records with a "!!" notation.

Zaidi and Guerzhoy used data on 8574 games from the chess website lichess.org, which had 820 moves marked as brilliant, to train a neural network to decide whether a given move would be seen as brilliant by people. When tested on real moves and real human reactions, it achieved this with 79 per cent accuracy.

The key to identifying brilliance lies in what is known as a game tree – the expanding web of possible moves that spread out from a given point in a match, says Guerzhoy.

The researchers found that a long, narrow path through a tree correlates with a move that is seen as brilliant. These might not be spotted by a typical AI chess model, which is likely to be analysing just a few moves ahead, while the long paths can look far further into the future and require more planning.

The pair also found that a tree containing a brilliant move may even look terrible until the final move (arXiv, doi.org/m5m4). That surprise success may be a key part of its brilliance.

"It shows the right spirit, because they're trying to make AI understand how humans view things"

"You'll have to go really deep in the tree to see that this is actually a successful strategy," says Guerzhoy. "That is something that people would find to be kind of aesthetically appealing."

He says the main aim of the research was to gain insight into how people perceive the aesthetics of chess, but it also paves the way for a chess AI that aims to make impressive moves, rather than just win. The researchers hope to unveil such a model in the coming months.

Chess grandmaster Matthew Sadler says AI has had a profound impact on chess, making some previously well-regarded tactics obsolete and throwing up new ones. "AI's taken away some stuff, but it's also put a lot back in. An awful lot of stuff that we never even considered was possible has been revealed by [AI] engines," he says.

Sadler says a model that can understand and emulate brilliance could be an essential training tool for professionals, and a more enjoyable opponent for amateurs.

"It kind of shows the right spirit, right? Because they're trying to make AI understand how humans view things," says Sadler. ▮

Zoology

Winter 'sauna' helps frogs fight off fungal disease

ONE of Australia's most endangered amphibians can fight off a deadly fungal infection with the help of a naturally heated shelter that has been dubbed a "frog sauna".

The disease, chytridiomycosis, has wiped out nearly 100 species of frogs, toads and salamanders around the world.

The green and golden bell frog (*Litoria aurea*) was once widespread in coastal south-eastern Australia, but has seen its range shrink by 90 per cent. While other factors, like habitat loss, are contributing, chytridiomycosis is thought to be the biggest threat.

To investigate ways to help, Anthony Waddle at Macquarie University in Sydney and his colleagues studied two groups of captive frogs that they infected with chytridiomycosis in winter, when many species are particularly susceptible to the disease.

They provided the first group with bricks with holes in, inside an unshaded "frog sauna" greenhouse shelter where temperatures reached nearly 40°C (104°F). The second group had the bricks in a shaded greenhouse shelter where temperatures hit 35°C (95°F).

In the warmer shelters, the amount of spores of chytrid fungus present on frog skin was 100-fold lower than in the other group (*Nature*, doi.org/m5mz).

ANTHONY WADDLE

Green and golden bell frogs basking in their artificial hotspot shelter

Chytrid fungus struggles to grow above 28°C (82°F), but the warmer temperature also seems to activate the frogs' immune system, says Waddle. "Using the shelters and surviving is like a vaccination," he says. "We have shown that the bell frogs can gain resistance after an infection is cured with heat and this can lead to a 22 times greater chance of surviving a future infection."

The researchers think the cheap shelter could also work for other amphibians threatened by chytridiomycosis. ▮

James Woodford

Events

NewScientist

Instant Expert

Inside the conscious mind

Saturday 7 September, 10am - 5pm | Conway Hall, London

The conscious mind acts like a conductor, orchestrating a symphony of sensations, perceptions, thoughts, and memories to create the unified narrative of a person's life. It allows us to experience the world around us and have a sense of self. Perhaps the greatest challenge facing neuroscientists today is understanding how this all arises from a complex network of just a kilo or so of brain cells.

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HURRY
Super early bird ends on 9 July

Speakers include:

Jane Aspell
Associate Professor of Cognitive Neuroscience, Anglia Ruskin University

Jonathan Birch
Associate Professor, Department of Philosophy Logic and Scientific Method, London School of Economics

Philip Burnet
Associate Professor and Director of Graduate Studies, University of Oxford

George Musser
Contributing Editor, Scientific American Magazine

More speakers to be announced shortly.

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Comment

Alien anxiety

Sci-fi depictions of extraterrestrial invasions can heighten illogical fears about our efforts to make first contact, says **Douglas Vakoch**

I HAVE been dreading the premiere of *A Quiet Place: Day One*, the just-released prequel to the movie franchise featuring blind but keen-hearing predatory aliens who invade Earth.

As a psychologist, I know that terrifying images from films and television shows can shape our judgements about real-world activities that seem superficially similar. As head of METI International, a scientific organisation that transmits powerful messages to nearby stars with the goal of messaging extraterrestrial intelligence, I know these vivid images of marauding aliens can provoke anxiety about research projects, even when our deepest fears can be rationally refuted.

Cognitive psychologists have identified several techniques that people use to assess risks when critical information is lacking. When we try to imagine something we have never encountered in reality, we are guided by the availability heuristic, which says we rely on the images most immediately accessible to us – that is, the most vivid ones.

When trying to imagine what first contact with an alien civilisation would be like, what could be more vivid than portrayals from blockbuster sci-fi horror films? And at a time when television networks are struggling to survive, which kind of first-contact scenario will lead to dramatic cliffhangers that build

ADRIÀ VOLTÀ

dedicated followers: an invasion by aliens intent on annihilating humanity, or "we come in peace"?

And as I discussed in a talk at the American Astronomical Society conference last month, television can also amplify fears of aliens by featuring scientific luminaries making comparisons with horrifying historical events. The late cosmologist Stephen Hawking said that if humankind receives a signal from extraterrestrials, we should stay quiet. "Meeting an advanced civilisation could be like Native Americans encountering Columbus. That didn't turn out so well," he said in a 2016 television show. If we let the aliens know we are here, he argued, we might be inviting an interstellar armada that could wipe out life on Earth.

But Hawking overlooked an essential point in all of this: Earth is anything but a hidden and quiet place. For 2 billion years, Earth's microbial life has been making itself known to the universe through changes to our planet's atmosphere.

In the next 20 years, humankind will have space-based observatories capable of spotting extraterrestrial life by studying the chemical composition of the atmospheres covering exoplanets. Advanced extraterrestrials would be likely to have even greater capacities.

Similarly, for the past century, Earth has been leaking radio and television signals into space, letting eavesdropping aliens know we have rudimentary technology. Broadcasts of *I Love Lucy* have been our interstellar emissaries since the 1950s.

Even though we might logically understand that it is too late to hide, one common cognitive bias leads to a nagging fear that it is somehow riskier to transmit than to remain quiet, so we should refrain. The omission bias makes us assume it is safer to do nothing than to do something; to continue with the status quo rather than try something different. The danger of giving in to this fallacy is apparent through the inaction of individuals who choose not to be vaccinated against the coronavirus, rather than to take action that benefits public health.

The most strident critique of METI International is that we threaten humanity by transmitting to other stars. But what critics must understand is that any aliens who can travel to Earth to annihilate us – like the fictional, sensitive-eared invaders of *A Quiet Place* – would already be able to tell that we are here.

Douglas Vakoch is president of METI International

No planet B

Hello, cool world

Demand for air conditioning will only grow as temperatures rise, sending energy consumption soaring. But there are some interesting solutions, finds **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

Graham's week

What I'm reading
I'll be on holiday in Mexico City when this is published, so probably an old-school guide book.

What I'm watching
We Are Lady Parts *on Channel 4.*

What I'm working on
A charming story about honey.

This column appears monthly. Up next week: Annalee Newitz

AS THE Paris Olympics and Paralympics approach, there are warnings the games could be the hottest on record, beating the current holder of that dubious title – Tokyo 2020 – and putting competitors at risk of heat exhaustion and potentially fatal heatstroke. In fact, average temperatures in Paris have risen by 1.8°C since the city last hosted the games a century ago. The reason is obvious.

The organisers are aware of the danger and have fitted an energy efficient system of underfloor pipes that carry water to cool the Olympic Village. Nonetheless, the US team has said that it will be installing its own air conditioning (AC) units, and several others are considering doing the same. These plans have reportedly miffed the mayor of Paris, Anne Hidalgo, who wants the games to be the most sustainable ever and doesn't want energy hungry air-con units busting their green credentials.

The heated tête-à-tête between greenness and coolness is one that will increasingly play out across the world as temperatures continue to climb and as people in low-income countries become more affluent. Both trends will vastly increase the demand for cooling tech such as air con and fans. In 2018, the International Energy Agency (IEA) warned this "cold crunch" is "one of the most critical yet often overlooked energy issues of our time".

The numbers are indeed chilling. In 2016, there were around 1.6 billion AC units in operation globally, responsible for 20 per cent of all the electricity consumed by buildings.

By 2050, the IEA forecasts that there will be over 5 billion AC units. All things being equal, their energy consumption will increase by the same factor. The number of household electric fans is also predicted to go from 2.3 billion in 2016 to 3.9 billion in 2050. They aren't as power-hungry as AC, but will still contribute to the cold crunch. According to the United Nations Environment Program, greenhouse gas emissions related to cooling are predicted to more than triple by 2050.

That is partly because AC units contain refrigerants, chiefly hydrofluorocarbons (HFCs), many of which are potent greenhouse gases. They inevitably leak from units that are faulty or have been badly disposed of. Thus we potentially enter a vicious circle

"Greenhouse gas emissions from cooling technology are predicted to more than triple by 2050"

where spiralling temperatures add to demand for cooling, which just exacerbates the problem.

Once an overlooked issue, the cold crunch is increasingly going mainstream. Shortly before the latest major climate talks – COP28 in the United Arab Emirates in December 2023 – a project led by the Africa Centre of Excellence for Sustainable Cooling in Kigali, Rwanda, and the UK's Centre for Sustainable Cooling at the University of Birmingham released a report arguing that cooling must now be considered critical infrastructure. As the report said: "The provision of cooling is not an optional extra or a lifestyle luxury. It is a critical service for a well-functioning, well-adapted, resilient, and healthy society and economy."

I'll throw my hat into that ring. I recently bought a new fan to make my bedroom bearable during the increasingly hot London summer nights, and would vehemently deny that it is a lifestyle luxury.

The message hit home at the COP talks: over 60 countries signed a voluntary agreement called the Global Cooling Pledge, which vowed to hugely increase access to cooling while actually cutting its emissions. The main tools for achieving this are decreasing the energy intensity of cooling technologies, early phase-out of the most damaging HFCs and wider adoption of passive cooling, such as insulation and green roofs.

These measures could reduce emissions from the cooling sector by 68 per cent compared with today, according to a UN report. We shall see – voluntary agreements at COPs have a history of over-promising and under-delivering. But if countries are serious, there is a cooling system on the way that could actually help reverse the underlying problem of too much carbon dioxide in the atmosphere.

Xi Chen at Columbia University in New York and his colleagues have designed a CO_2 purification module to be added to existing AC units. It captures CO_2 from indoor air and locks it away in a material called a sorbent.

The principal goal is to cut indoor air pollution, but if widely used, Chen says this could suck CO_2 out of the atmosphere in quantities dwarfing those currently possible or economically feasible with the outdoor-air equivalent, an industrial endeavour known as direct air capture (DAC).

One big problem with DAC is that CO_2 concentrations in the atmosphere are so low. But put a load of people in a building, all exhaling CO_2 all day long, and that problem disappears. Enough, indeed, to use indoor DAC to bring global CO_2 concentrations down to pre-industrial levels. Cool. ▮

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Sale prices apply to selected items only whilst stocks last. Sale ends 12pm BST on Monday 15 July 2024.

Unreal history

Photographer Tonje Bøe Birkeland

THE imagined female scientists, explorers and adventurers seen in Tonje Bøe Birkeland's photographs are echoes from a footnote in women's history. In her ongoing series, *The Characters,* the photographer frames herself in the guise of Victorian and early-20th century pioneers – dressed in period costume, holding binoculars and bellows cameras – snapped in widescreen vistas of mountains, fjords and ice flows. Each picture is a performance.

The project began in 2008, when Birkeland was on a course about photography's role in shaping historical truths. "It was all about did Neil Armstrong go to the moon? Did Roald Amundsen actually get to the Pole first?" she recalls. "That made me want to do something about women." Her first character was a glaciologist.

Her photographs are puzzles and her work taps into the names, appearances and biographies of real, unrecognised women, such as Louise Arner Boyd, a polar scientist who traversed the north-east coast of Greenland in the 1920s. As well as stepping into the boots of her creations, Birkeland writes their journals and creates installations of their travel cases (packed with maps and geological samples), which she both photographs and exhibits. She has immortalised her intrepid alter egos in various settings, from the snowdrifts of Svalbard to the foothills of Bhutan.

In the top photo at immediate left, she is seen as desert traveller Tuva Tengel on a camel in Mongolia. The three other photos show her as Arctic explorer Anna Aurora Astrup in Greenland.

Birkeland's work will be at Forum Box in Helsinki, Finland, from 22 August to 19 September.

Christian House

Editor's pick

No doubt about it, babies are conscious

15 June, p 19

From Talia Morris, Cape Tribulation, Queensland, Australia

It is amazing that there are still doubts about whether human newborns are conscious and capable of experiencing pain.

Newborn foals and calves are born with their eyes open and are capable of walking almost immediately after birth. I have been at the birth of several spectacled flying foxes, amazing events to witness. As soon as the pup's head emerges, not only are its eyes wide open, its little ears are swivelling, listening to everything. Even more interestingly, the pup will produce its first vocalisations to let its mum know that all is well.

Why is there any expectation that human infants are born with less awareness than other mammals?

From Louise Quigley, Braintree, Massachusetts, US

I can't believe that scientists are conducting experiments to find out what every parent has known since the dawn of humanity, the moment they look in their baby's eyes just seconds after it takes its first breath: there is someone there. An ignorant, inexperienced, inarticulate someone, to be sure, but a person ready to be met, cared for and taught.

Furthermore, anyone who ever accidentally stuck a newborn with a diaper pin knows they can feel pain – and protest the experience loudly.

In defence of the new breed of weight-loss drugs

Leader, 15 June

From Carl Zetie, Raleigh, North Carolina, US

Much of the backlash against "easy" weight loss via Wegovy and other GLP-1 drugs comes from culturally entrenched moralising, people leaping to judge others as "lazy" or "greedy" and not deserving to lose weight if they don't "put in the work".

The fact that these drugs are so effective shows that, in many cases, people who are overweight simply have ill-regulated hunger hormones. Taking Wegovy to help manage weight should be no more controversial than insulin for diabetes or SSRIs for depression.

Time to get on with tests of this geoengineering

8 June, p 15

From Mike Graham, Peterborough, Cambridgeshire, UK

So sulphur dioxide emissions from ships burning heavy marine fuel cooled Earth by brightening ocean clouds, but declines in such pollution since 2020 have resulted in warming. This unplanned experiment in geoengineering indicates that we should now fund tests of marine cloud brightening using ships to spray seawater into clouds to cut temperatures, as proposed by the late Stephen Salter.

Species counts can fail to capture biodiversity

25 May, p 36

From David Barden, Llantrisant, Mid Glamorgan, UK

Having read your piece about how to measure biodiversity, it is worth remembering that although the species concept is immensely useful, it does have its limits. This is because species descriptions, in order to be practical, have to encompass a lot of variation between individuals, both in their outward characteristics and their genetic codes.

For example, species in the marsh orchid genus (*Dactylorhiza*) readily interbreed to produce lots of fertile plants spanning the whole spectrum of characteristics. In such cases, a simple species count can't easily capture the true diversity present.

No surprise that microbes are eating plastic waste

22 June, p 16

From Sam Edge, Ringwood, Hampshire, UK

I was heartened to read of another organism that has taken to consuming one of our throwaway polymers. To be fair, given the high energy density of plastics, it isn't surprising that microbes are evolving to feed on them.

I agree with Annika Vaksmaa about the dangers of introducing this fungi, *Parengyodontium album*, outside its existing ecology. In fact, it occurs to me that if we encourage plastic-eating microorganisms by selective breeding or gene editing, we might end up hoisted by our own petard. The non-biodegradability of plastics is one of the main reasons we use them, after all.

Let's hope fiction doesn't become fact

22 June, p 40

From Barry Isaacs, Lamerton, Devon, UK

I see with some alarm that you describe the New Horizons spacecraft as "plucky" – a term usually defined as having courage in the face of adversity. This seems to imply that the probe has acquired intelligence, can understand what it is doing and experiences human emotions.

This isn't far removed from the plot of *Star Trek: The Motion Picture*, where an earlier spacecraft leaves the solar system, only to return centuries later and wreak havoc while it tries to locate its creator: NASA's Jet Propulsion Lab.

There is simply no safe amount of alcohol

15 June, p 28

From Dan Roach, Rochdale, Greater Manchester, UK

I take issue with claims that scientists are fairly unanimous that drinking alcohol in moderation is healthy. While I agree that this is preferable to excessive drinking, there is no amount of alcohol consumption that doesn't affect health. In fact, the World Health Organization published a statement on this in January 2023.

On the strange result of the double-slit experiment

Letters, 22 June

From Eric Kvaalen, Les Essarts-le-Roi, France

There is some misunderstanding about interference in the double-slit experiment. The electron doesn't interfere with the next electron, but with itself.

Many good reasons not to tip rubbish into a volcano

Letters, 22 June

From Alex McDowell, London, UK

Robin Stonor asks why not throw rubbish in a volcano. On contact with hot lava, many materials would vaporise, causing explosions. Due to the lack of oxygen, plastics and organic materials would decompose, not burn – this would produce flammable and toxic gases, including greenhouse gases.

For the record

In salt sensitivity, each extra gram of sodium per day raises blood pressure by an average of 2.1 mmHg (8 June, p 32).

A Kuiper belt object in a 2:3 resonance with Neptune completes two orbits of the sun for every three orbits the planet makes (22 June, p 40).

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters

Letters sent to New Scientist, 9 Derry Street, London, W8 5HY will be delayed

Help save the gibbons and win some incredible prizes!

ENTRY DEADLINE EXTENDED TO 14 JULY

Build THE Change

The deadline for the *New Scientist* and the LEGO Group's social impact program competition has been extended to 14 July 2024, giving you more time to come-up with a fantastic idea to help the gibbons navigate their fragmented habitats! Can you design bridges between tree gaps or find innovative ways to help gibbons find their mates through song? Or do you have another idea to help gibbons navigate the threats they are facing.

Finalists will get to work with LEGO® Master Builders to build their solution at New Scientist Live, and their ideas will inspire a real-life invention built by engineers at Imperial College London. The winners will be announced at the New Scientist Live, 12-14 October at ExCeL London.

Join the competition and use this extra time to perfect your ideas!
The competition is open to UK residents* aged 11-14 and includes two categories: i) Schools and ii) General public.

Find out more

newscientist.com/gibbons-competition

*Except residents from Northern Ireland. Please see newscientist.com/gibbons-competition for full terms and conditions

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Relax with some great science

Want to save our seas? Make exotic cocktails? Ponder life's meaning? Whatever your plans this July, **Simon Ings** rounds up the year's best non-fiction so far

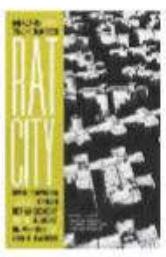
Embrace the rat race

LUZA STUDIOS/GETTY IMAGES

READERS of *New Scientist* aren't known for their pursuit of mindless pleasure. Many of you are dedicated to your work or to keeping up with your field, which tends to be a bit more interesting than the average 9 to 5. It's a wonder you take time off at all and, even then, lots of you remain strangers to holiday excesses.

We could try scaring you onto that beach or up that mountain. What if we remind you that, while you are at home, especially since many of you live in cities, you are said to be never more than a metre or two away from a rat?

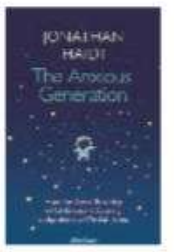
But then again, as a *New Scientist* reader, you are unlikely to credit such a hackneyed statistic. You may also be aware of journalist Joe Shute's *Stowaway: The disreputable exploits of the rat* (Bloomsbury Wildlife), which aims to scotch many a myth on the way to celebrating this supersocial animal. How such an easily domesticated creature became everyone's idea of a harbinger of death makes fascinating and prejudice-busting reading.



In the 1950s, in an effort to improve the way we build and run our cities, ethologist John Calhoun used rats as animal models, creating a variety of configurations of "rat city". Social historians Jon Adams and Edmund Ramsden chart his peculiar experiments in *Rat City: Overcrowding and urban derangement in the rodent universes of John B. Calhoun* (Melville House). They conclude that, when it comes to civil order, we could learn a thing or two from our whiskered brethren.

But perhaps our best chance of scaring you into that holiday may be to remind you that, wherever you are at work, you are rarely more than a couple of metres away – from other people. Now there's one animal we really do have to worry about.

There has been much argument (and some pushback) about social psychologist Jonathan Haidt's jeremiad against the smartphone, *The Anxious Generation: How the great rewiring of childhood is causing an epidemic of mental illness* (Allen Lane, UK; Penguin Press, US). Haidt's impassioned



attempt to give a statistical foundation to our concerns about young people's deteriorating mental health has made his book an international water-cooler hit – and one inspiring many people to at least experiment with a marked reduction in their smartphone use (for as long as the vacation lasts, that is).

All this assumes that, having left for your holidays, you can actually get anywhere. Good luck negotiating the hordes of shambling smartphone addicts cluttering the mouths of lifts and milling around at the bottom of escalators. Readers convinced we are living through some sort of outtake from a George Romero zombie movie will appreciate sociologist Allison Pugh's *The Last Human Job: The work of connecting in a disconnected world* (Princeton University Press, out in

Save our seas

The story of our relationship with the ocean grows ever more complex. In *What the Wild Sea Can Be: The future of the world's ocean* (Grove Press, UK; Atlantic Monthly Press, US, out 16 July), marine biologist Helen Scales explains how our prospects are intimately bound up with that of the ecosystems in the sea.

In this snapshot of the state of our oceans, there are plenty of scare stories. For example, the sea ice that connects to solid land is weakening earlier in the year, which can force emperor penguin chicks into the water before they develop the waterproof feathers they need to survive.

But benign human innovation and the natural resilience of marine ecosystems may turn the tide. Scales is a wonderful guide to the tragedy and the triumph of taking our ocean in hand.

REINHARD DIRSCHERL/ALAMY

the UK on 30 July). Commercial logic, coupled with technology, is eroding the spontaneity of human contact. Pugh's message is plain: we have to make a concerted effort, in the workplace and in our lives, to revive our social worlds.

Great train reading

Holiday-making can itself be a lonely business. To while away those sleepless hours on long train journeys, a good book is vital.

On the strength of the title alone, what could be more fitting for discombobulated travellers than Robyn Arianrhod's *Vector: A surprising story of space, time, and mathematical transformation* (University of Chicago Press).

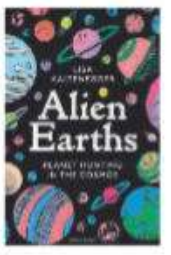
Not only will readers acquire the mathematical ability to determine forces on an amusement park ride (a vital part of parental arsenals), they will also discover how an elegant piece of mathematical notation has changed the way we think about the world.

A more straightforwardly imaginative getaway is served up by science writer Rebecca Boyle in *Our Moon: A human history* (Hodder & Stoughton), which traces the moon's physical, historical and psychological influence over our species. Our reviewer, Abigail Beall, particularly liked how Boyle wove in so many historical perspectives, from palaeontology to her own family history.

If you want to carry your imagination even further, then astronomer Lisa Kaltenegger is bound for worlds of scientifically bounded speculation in *Alien Earths: Planet hunting in the cosmos* (Allen Lane, UK; St. Martin's Press, US). A new generation of telescopes, even now under construction, will usher in a historical shift in the way we look at the night sky, says Kaltenegger, whose book intertwines science with her own professional experiences, including the deployment of the James Webb Space Telescope and the first discovery of Earth-like planets at the right distance from their star to host liquid water.

It is a complex book, with plenty to ponder on a long journey. How did life emerge on Earth? What are the most unusual exoplanets – and how can we find them? Not forgetting, especially in the wee small hours of the night, the killer question: how do we define life?

Kaltenegger also makes a vital point about the sexism in her field. Her personal reflections about her career may strike some as jarring alongside the "real" science, but, as she explains, the best chance for humans to succeed in their mission to discover alien life is to have "the broadest, the most diverse, spectrum of thinkers working together". Everyone is needed on this quest of quests.



Time to binge

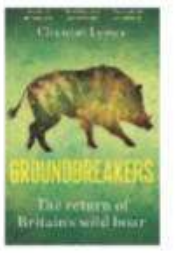
Once you hit that beach, forest cabin or (insert ideal destination here), all reading bets are off.

But let's just add a few lovely but light science reads – just to prove that this isn't a contradiction in terms. First, try David Darling's delightful *Ka-boom! The science of extremes* (OneWorld). This compendium of the largest, smallest, stickiest, loudest, fastest and slowest phenomena in science contains, among other marvels, the speed record for a sloth (but that would be telling).

And if you are feeling peckish, then a chapter or two of *Flavorama: A guide to unlocking the art and science of flavor* (Harvest) will have you heading for the kitchen. Flavour scientist Arielle Johnson piqued the appetite of reviewer Sam Wong for adventurous chemistry, in particular by explaining how flavours have been extracted, concentrated and transformed by different culinary traditions. And that's not to mention all the other extraordinary information she feeds us: who knew that we have 400 types of smell receptor that let us recognise perhaps as many as a trillion aromas?

Plus, there are exotic recipes, including coffee-infused rum, and smoke-infused oil made with lapsang souchong tea. Others are ambitious, like the vinegar, crème fraîche and pumpkin seed miso.

After that, it is time for a walk. Chances are you are taking your break in the countryside, but if you think that the rural environment holds no more surprises, think again. Even better, read the amazing *Groundbreakers: The return of Britain's wild boar* (Bloomsbury Wildlife) in which naturalist Chantal Lyons visits the Forest of Dean in south-west England to meet a population descended from boar released illegally in the 1980s.



No one can say what you may find around the next corner – though it is a pretty safe bet that someone, somewhere, has written a book about it. ▮

Simon Ings is a writer based in London. His latest book is *Engineers of Human Souls*

Psychedelic paradox

Ernesto Londoño used to report from war zones. Years later, he realised something was wrong when he considered taking his life. He knew soldiers with post-traumatic stress disorder, so he recognised what he was dealing with and knew how poor the standard treatments were. As a journalist, he decided to try something fashionable: ayahuasca tea. Even if dabbling in psychedelic medicine didn't help him, it might make a book.

Trippy: The peril and promise of medicinal psychedelics **(Orion Spring, UK; Celadon Books, US) is the result, a fast-paced but deep and personal investigation into the promise psychedelics hold for mental health conditions.**

Londoño swears by the tea (chunks of the Amazonian vine *Banisteriopsis caapi* are boiled with the leaves of a shrub called *Psychotria viridis* – not at home, please). But he is well aware that a medicine that is part plant extract, part complex and thoughtful ritual doesn't fit easily with typical Western prescriptions.

Equally, abandoning what we do know can be an easy path to silliness and quackery (his criticisms of psychedelic culture are caustic and funny). To reap the benefits of psychedelics, we will need a more balanced perspective. *Trippy* is a valuable first step.

Don't forget to pack the sci-fi...

From a quantum-bubble reality show to a murderous valet bot, enjoy this year's best science fiction so far if you are heading on your travels, says **Emily H. Wilson**

SINCE I became science fiction columnist for *New Scientist*, I have had to think a lot about what qualifies as sci-fi. Very often, a book could actually be classified as fantasy, which is outside my remit. More and more, I find myself agreeing with the writer Damon Knight when he said: "Science fiction is what I point to [when I say] 'That's science fiction'."

Anyway, for this holiday reading special, I present my list of some of the year's best sci-fi so far. All that binds these incredibly diverse books together is that I am pointing at them and saying: "Here is some good science fiction." But I do hope you enjoy them.

In *All This & More* by Peng Shepherd (HarperCollins; 9 July US, 15 August UK), reality TV contestants enter a "quantum bubble", allowing them to change anything they want about their life, with real-world consequences.

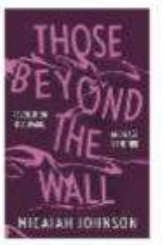
Explore books dealing with multiverses and alternate worlds

Our hero, Marsh, is a divorcee in her mid-40s who gave up her legal dreams when she got pregnant. Can she use the show to resurrect her career and even her marriage?

In theory, you can skip around this unusual book, making your own choices about what Marsh should do in the quantum bubble. But I read it straight through and it worked fine. Physics and ethics experts may need a long lie-down afterwards, but the novel is deft, inventive and takes you with it.

The Siege of Burning Grass by Premee Mohamed (Solaris) is a gritty yet poetic read set on a war-torn world with floating cities, healing wasps and senseless violence. Our hero, Alefret, is a one-legged, hulking pacifist who makes an endearing protagonist as he slogs across a ghastly landscape in the company of a psychopathic soldier who may or may not be able to help him end the war. The author calls the book "second-world fantasy", but if *Dune* counts as sci-fi, so does this.

Those Beyond the Wall by Micaiah Johnson (Del Rey) is also second-world fantasy, this time one where hopping around the multiverse is possible. There are *Mad Max* vibes as our hero, Scales, fights for survival and also honour in an apartheid world where white people guard their wealth behind high walls. In a foreword, Johnson says she wrote the novel as a reaction to her time at the 2020 sit-ins at the Tennessee State Capitol in Nashville in the wake of the murder of George Floyd by a police officer. She dedicates the new book to "anyone who has stood against injustice". You won't be surprised, then, that anger rises up off every page, but there is also tenderness, vivid world-building and flashes of infectious humour.

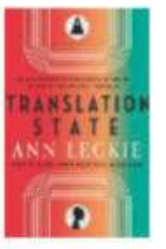


Tim Pratt also provides some multiverse action with *The Knife and the Serpent* (Angry Robot). It is very light fare, but jolly. Be warned (or delighted) that it contains a lot of talk about kinky sex.

Let me also remind you of books I have reviewed this year that I think you will enjoy, including *Annie Bot* by Sierra Greer (Mariner Books), written from the viewpoint of a sexbot, and *Service Model* by Adrian Tchaikovsky (Tor), written from inside the head of a murdering valet robot. They make interesting companion pieces.

"Micaiah Johnson dedicates her new book to anyone who has stood against injustice"

Alien Clay (Tor), also by Tchaikovsky, has creepy alien biology, mystery archaeology and a prison camp on a faraway planet. It is very much in the traditional sci-fi mould, there being spaceships and all. That reminds me: if you missed Ann Leckie's *Translation State* (Orbit) in hardback last year, it is now in paperback. It is a triumphant return to the Radch universe, offering deeper insight into the mysterious, violent yet often very comic Presger aliens. Happy reading! ▮



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Emily H. Wilson is a former editor of *New Scientist*. She is the author of the Sumerians trilogy; the second in the series, *Gilgamesh*, is out next month

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Immune to ageing

It may soon be possible to vaccinate ourselves against diseases of old age. **Graham Lawton** investigates

JON KRAUSE

IN JUST over five years I will turn 60, which is a daunting prospect. I already have one age-related disease – hypertension – and, given the odds, will be lucky not to have been diagnosed with at least one more by then. After that, age-related conditions are likely to pile up until the inevitable end. It will be a similar story, no doubt, for many of you. We are living longer than before, but those extra years aren't necessarily healthy ones.

Yet if recent developments are anything to go by, my sons may be luckier. Rather than face a laundry list of common ailments in their 70s and 80s, they may be able to immunise themselves against them. They could celebrate middle age with a vaccination that will make them immune to Alzheimer's, cancer or hypertension. They might even get an anti-ageing panacea that will vaccinate them against all of the above and more, helping them face their later years in a healthier state than most of us can hope for today.

In the battle against the diseases of old age, an age-old medical technology suddenly looks like a game changer. Vaccines, the injections that we most commonly associate with infectious diseases such as covid-19 and measles, are now showing promise in treating non-infectious diseases – particularly those associated with advancing years. So rapidly is this field progressing that, given a fair wind, there are hints that I – and others my age – may even benefit from some of these vaccinations ourselves. It sounds too good to be true, but vaccinating against the worst aspects of ageing is looking more like a question of when, not if.

The first successful vaccine was for smallpox, invented in 1796 by Edward Jenner. Such jabs now exist for most infectious diseases and are arguably one of the most effective medical interventions to date. A recent analysis found that, since 1974, vaccines have averted 154 million deaths worldwide, including 146 million among children under 5.

The rationale of vaccination is to present the immune system with small chunks – called antigens – of an infectious organism to provoke an immune response and lay down an immune memory so that subsequent contact with the real pathogen is quickly dealt with.

It is fairly easy to elicit a useful response from the immune system in reaction to an infectious agent because the body recognises it as being "non-self". Non-infectious diseases, on the other hand, arise from a person's own cells, which makes it more challenging to spark such a response – but not impossible.

The first non-infectious disease to be targeted by vaccination was cancer. In the early 1980s, a team at Johns Hopkins University in Maryland injected 20 people who had colorectal cancer with their own cancer cells mixed with the BCG vaccine, originally developed against tuberculosis but known to also be a general immune-system stimulator. The idea was to raise an immune response to the participants' own tumours.

Just over two years later and all 20 were still alive, whereas four of the 20 people in a control group had died, a statistically significant difference. Other trials using the same technique found similar positive outcomes.

Cancer vaccines are different from traditional vaccines: they are therapeutic rather than prophylactic. But they still qualify as vaccines. "A vaccine is anything that stimulates the immune system in a way that benefits the host," says Howard Weiner at Harvard Medical School, who is working on their use as treatments, including for Alzheimer's disease.

Progress on cancer vaccines has been slow, though. Cancer cells are exceptional at hiding from the immune system, not least because they are cells that originate from the person's own body. So far, there have been more than 600 clinical trials for cancer vaccines. As yet, however, only one has made the grade and its impact has been moderate. Provenge for prostate cancer was approved in the US in 2010 but hasn't set the world on fire, according to Samir Mitragotri at Harvard University. It is relatively expensive, has only a modest benefit and isn't considered cost-effective.

"These vaccines will be given not only to treat Alzheimer's, but to help prevent it"

But hope springs eternal. Many cancer cells turn out to be studded with antigens not normally present in the human body. These "neoantigens" often arise through genetic mutations within the cancer cell and can present a juicy target for the immune system. The discovery of neoantigens has helped to rejuvenate the field, says Nina Bhardwaj at Icahn School of Medicine at Mount Sinai in New York. A recent human trial using a molecule called mRNA to stimulate the production of neoantigens showed promise in flagging melanoma skin cancer cells to the immune system, for example.

The stuttering progress of this approach for cancer hasn't dampened the belief that non-infectious diseases can be targeted by vaccination. Many age-related conditions, in particular, are characterised by the excessive accumulation of specific proteins, which can be exploited by vaccines to evoke an immune response.

Alzheimer's disease, for instance, has long been associated with the build-up of certain forms of two proteins, beta-amyloid and tau, in and around brain cells. The exact role these play in the disease is controversial, but they ›

ARIEL SKELLEY/GETTY IMAGES

Anti-ageing vaccines could keep us feeling younger for longer

remain two of the strongest candidates we have as causative agents.

Vaccines are in development against both, and they are badly needed. This debilitating and ultimately fatal condition is the most common form of dementia. In 2023, an estimated 6.7 million people in the US aged 65 and older were living with Alzheimer's, and that number could grow to 13.8 million by 2060 without a swift medical breakthrough. Current treatments are extremely limited.

According to Guanghui Liu at the Chinese Academy of Sciences in Beijing, there are six ongoing clinical trials of vaccines against beta-amyloid or tau. The idea behind them is fairly straightforward: the vaccine contains an active ingredient designed to stimulate the immune system to produce antibodies against the proteins. The antibodies cross the blood-brain barrier, bind to the proteins and trigger white blood cells to clear them out in the hope that this slows the progression of the disease.

But there was a challenge: both beta-amyloid and tau are normal proteins expressed in the brain, and hence tolerated by the immune system. However, in their pathogenic form, these proteins are misfolded. This difference presented a novel target, says Liu. The trick is to turbocharge the natural immune response to these misfolded versions of the proteins with vaccine additives called adjuvants, which alert the immune system to danger.

Swiss biopharmaceutical company AC Immune has two Alzheimer's vaccines doing just this in early-stage human trials, one against each protein. The ultimate goal, says company spokesperson Gary Waanders, is to vaccinate people at the very earliest stages of Alzheimer's to slow or halt disease progression. That may mean people who have yet to develop any symptoms at all. A recently developed blood test can spot the stirrings of tau-related pathology before any cognitive deterioration appears. "The vaccines will ultimately be given not only to treat Alzheimer's, but to help prevent it," says Weiner.

My hope while researching this article was that my sons may have the opportunity to try such vaccines, but Waanders hints that I might also be in with a chance of receiving it. He says that AC Immune's beta-amyloid vaccine might make it on the market as soon as 2029 if everything goes smoothly.

Meanwhile, the US Food and Drug Administration recently granted another amyloid-busting vaccine – UB-311 from biotech company Vaxxinity in Cape Canaveral, Florida – a fast-track designation, so that it can be expedited through its review process. It has shown promise in human trials, says Vaxxinity CEO Mei Mei Hu, with 98 per cent of people responding to the vaccine. "They developed antibodies. These antibodies crossed the blood-brain barrier. They engaged the target. We slowed cognitive decline by about 50 per cent." UB-311 is currently on track for a larger trial that will include around 3000 people.

Straight to the brain

There are other ways of leveraging the immune system to clear out beta-amyloid. Scientists at the Ann Romney Center for Neurologic Diseases in Boston, Massachusetts, led by Weiner, are testing a vaccine that is administered nasally to activate the immune system in lymph nodes in the neck and from there send immune cells called monocytes into the brain. "The monocytes go and clear amyloid," says Weiner. The vaccine has been shown to remove beta-amyloid in mouse models of Alzheimer's and is heading into early human trials.

Clearly, there is no guarantee that any of these Alzheimer's vaccines will make it into use. Numerous experimental ones have already fallen by the wayside, either due to lack of efficacy or adverse reactions.

Regardless, hopes remain high that these obstacles can be overcome. "One day, we will be treating and preventing Alzheimer's with vaccines," says Weiner. "Of course, it doesn't happen overnight. But we're doing it."

Something else my sons may be interested in following is the progress of vaccines for vascular system diseases. Like hundreds of millions of others around the world, I have hypertension, or high blood pressure, and, as it tends to run in families, they are both at higher risk of developing it too.

Current first-choice therapies – drugs known as calcium-channel blockers and ACE inhibitors that prevent blood vessel narrowing – are effective, but don't tackle the root cause, according to Yuhua Liao at Huazhong University of Science and Technology in Wuhan, China.

The primary regulator of blood pressure is a receptor in the arteries. When activated, it causes blood vessels to constrict and blood pressure to rise. The receptor can be deactivated with drugs called alpha-1 blockers, but they lack specificity and have a short lifetime in the blood, so they aren't prescribed as front-line drugs. To solve this problem, in 2019, Liao and colleagues tested a vaccine that elicited antibodies that blocked the arterial receptor in mice, with promising results.

The upshot is that there is solid progress with single-target vaccines of this sort, and the list of potential conditions of older age that could be treated this way goes on. There are versions in trials that attempt to fight osteoarthritis, Parkinson's disease and even high cholesterol. But while vaccines for individual conditions are indeed a welcome addition to our armoury, there is one more vaccine candidate that I have been following particularly closely.

It is a general-purpose anti-ageing vaccine

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and its target is senescent cells. These cells have suffered some sort of irreparable damage and stopped dividing, but they don't die. They are usually cleared out by the immune system, but this process falters with age and senescent cells build up in tissues, secreting a potent cocktail of inflammatory molecules in a vain attempt to summon an executioner. Left unchecked, these secretions are highly toxic, damaging surrounding tissues and leaching into the bloodstream. Recent research suggests that a build up of senescent cells is a contributing cause of several diseases of older age.

Numerous drugs that appear able to destroy senescent cells are already being tested and have shown early promise in more than 40 different age-related diseases, according to James Kirkland at the Mayo Clinic in Rochester, Minnesota. Multiple clinical trials are ongoing, but, as yet, only two have reached the stage at which a large number of people have been given the drug or a placebo to test effectiveness and, according to Benjamin Le Calvé at pharmaceutical company StarkAge Therapeutics in Lille, France, their benefits have thus far proved limited. The classical drug approach has "probably reached its limits in term of clinical development", he says.

A big problem is that most of these "senolytic compounds" work by reversing senescent cells' steely refusal to activate a self-destruct mechanism called apoptosis. But the drugs can also push healthy cells down the same pathway, which raises the possibility that they will damage non-target tissues.

> "Mice vaccinated against zombie 'senescent' cells lived longer and in better health than those given a placebo"

That is where vaccines come in. Senescent cells commonly express very high levels of antigens that are absent or scarce in non-senescent cells. These "seno-antigens" are a cry for help to the immune system, which rounds up troops to dispose of them. The belief is that vaccines that target seno-antigens can help boost the immune system's response, destroying senescent cells while leaving healthy ones alone.

ASSOCIATED PRESS/ALAMY

Vaccines could help clear beta-amyloid (brown) and tau (blue), proteins linked with Alzheimer's

The end of ageing?

In 2020, a team led by Hironori Nakagami at Osaka University Graduate School of Medicine in Japan created a vaccine against a seno-antigen called CD153, which is present on the senescent cells that accumulate in the visceral fat that is found on and around organs. Mice given the vaccine, then fed an obesity-inducing diet, had much lower levels of these senescent cells than regular obese mice and had improved glucose metabolism and reduced insulin resistance. This seminal study not only shows that senescent cells can be eliminated by vaccination, but also that this improves important physiological functions, says Liu.

A year later, a team led by Tohru Minamino at Juntendo University Graduate School of Medicine in Tokyo, Japan, did something similar. This time, the work involved aged mice and senescent cells in the lining of their blood vessels, which are a known risk factor for atherosclerosis, the process by which arteries narrow and stiffen. The vaccinated mice had a longer healthspan – a measure of how long they remained in good health – and a longer lifespan than those that received a placebo.

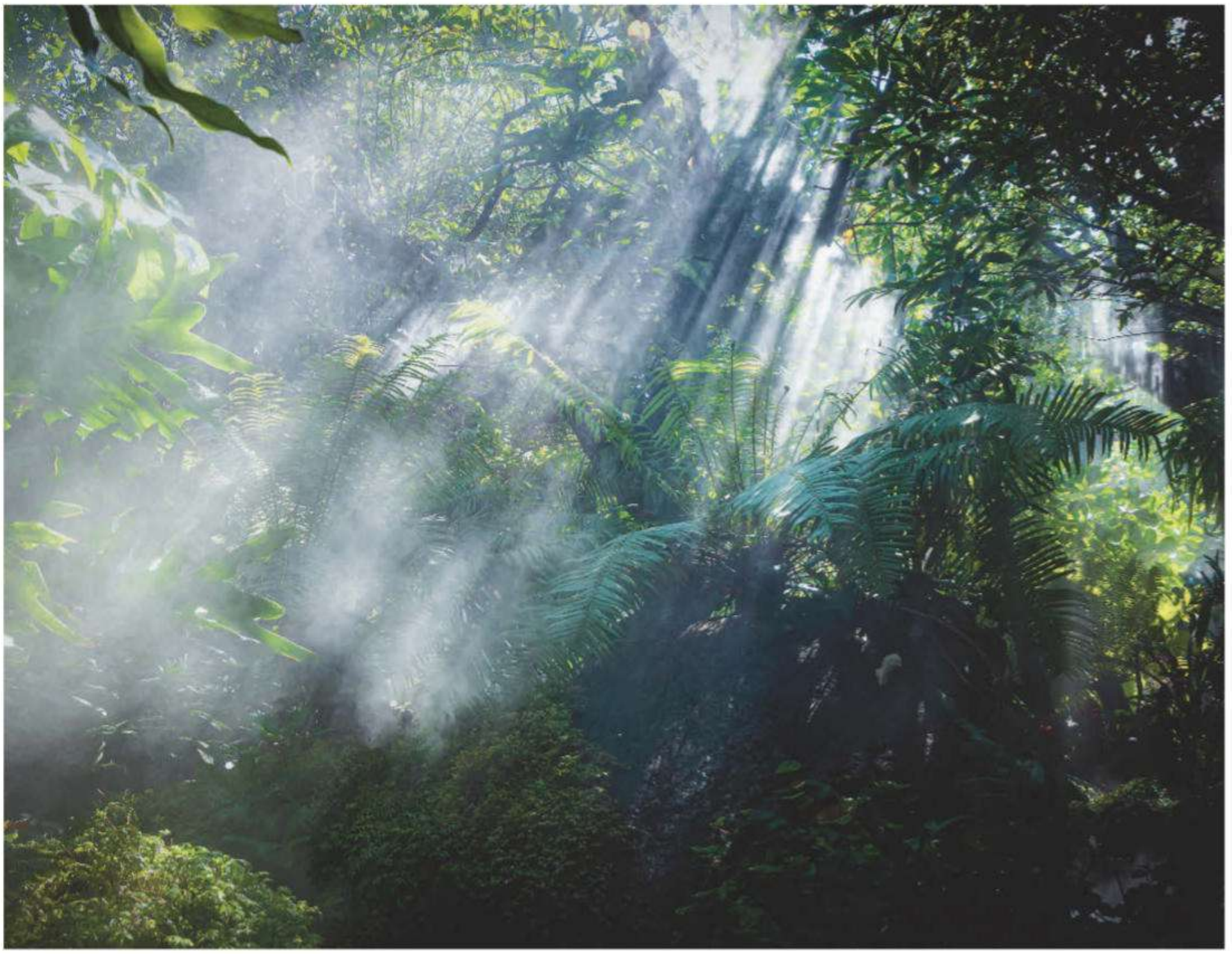
This is all encouraging. "What's clear is that harnessing the immune system represents a new and potentially powerful strategy to clear senescent cells," says Toren Finkel at the University of Pittsburgh in Pennsylvania.

While there is progress on various fronts in the fight against senescent cells, the first area where such vaccines might actually make an impact is cancer, neatly bringing the promise of anti-ageing vaccines full circle. Senescent cells are much more visible to the immune system than cancer cells. Combine the two, and bingo. Cancer cells sometimes become senescent naturally. This can be induced artificially by extracting and irradiating them. Experiments in mice have shown that injecting such cells back into the animals – or doing the same with immune cells exposed to the senescent cells – can evoke a strong anti-tumour immune response.

In one recent experiment, for example, a team at Seoul National University in South Korea took cells from tumours in mice, induced them to become senescent and then extruded them through a tiny, sieve-like membrane to create minuscule particles. Injecting the particles back from whence they came elicited a strong immune response and inhibited the growth and spread of the tumour. The researchers say the procedure is straightforward and could be developed to make personalised cancer vaccines.

As yet there are no senescent-cell vaccines in clinical trials, but efforts to test them in people are expected, according to Liu, and their potential is clear. "Further advancements are necessary, but senolytic vaccines offer a promising strategy to alleviate morbidity, ultimately improving the overall health and well-being of individuals in their later years," he says. That is good news for my sons – and maybe I too will live long enough to benefit, helped on my way by other anti-ageing vaccines. ▮

Graham Lawton is a staff writer at *New Scientist*



JOEL CARILLET/GETTY IMAGES

Urban jungle

Lost cities emerging from beneath the Amazonian rainforest are revealing a fresh perspective on the development of prehistoric civilisations, finds **Colin Barras**

TRY to imagine an environment largely untouched by humans and the Amazon rainforest might spring to mind. After all, large swathes of this South American landscape are blanketed in thick vegetation, suggesting it is one corner of the world that humans never managed to tame. Here, there must have been no deforestation, no agricultural revolution and no cities. It seems like a pristine environment.

Or so we thought. But a very different picture is emerging. Archaeologists working with Indigenous communities have been shown crumbling urban remains and remote sensing technologies such as lidar are revealing the footprints of vast ghost cities. With so much evidence of ancient human activity, it is now thought the pre-Columbian Amazon was inhabited by millions of people – some living in large built-up areas complete with road networks, temples and pyramids.

But that's not all this research reveals. Paradoxically, it also provides evidence that the traditional view of the Amazon isn't completely wide of the mark. For instance, while the ancient Amazonians managed their landscape intensively, they didn't deforest it. And although they developed complex societies, they never went through a wholesale agricultural revolution. This might suggest that the pre-Columbian Amazonians broke the mould of human cultural development, which is traditionally seen as a relentless march from hunting and gathering to farming to urban complexity. The truth is more surprising. In fact, we are now coming to understand that there was no such mould – civilisation arose in myriad ways. What looks like an anomaly in the Amazon is actually a shining example of a process that was as vibrant and diverse as the rainforest itself.

Despite its obvious biodiversity, the Amazon rainforest is rooted in impoverished soil. This realisation led to the long-held belief that it couldn't sustain large numbers of people. The first hint that this assumption might be wrong came in the 1960s, with the suggestion that mysterious patches of fertile soil, known as terra preta, were created by past societies to boost crop growth. The scale of these societies began to emerge three decades later, when Michael Heckenberger at the University of Florida in Gainesville began working with the Kuikuro, an Indigenous group who live in Brazil's Upper Xingu region. "After two weeks, the Kuikuro chief, Afukaka, took me to a site that was 20 times as big as the contemporary village," says Heckenberger. "Then he took me to another." Clearly, Afukaka's forebears had built on a grand scale. How was this possible?

"The pre-Columbian Amazon was inhabited by millions of people"

Discoveries made this century have finally allowed us to answer that question. The story begins when humans first arrived in the Amazon. Exactly when that happened is up for debate – estimates vary from 27,000 to 13,000 years ago – but it seems to have been remarkably soon after people arrived in the Americas. Those early Amazonians didn't immediately start building large settlements deep within the rainforest. Instead, they stuck to the margins of the Amazon basin where an astonishing variety of landscapes still exists. "There are lush evergreen forests, seasonally flooded savannahs, huge areas of wetlands – it's very diverse," says José Iriarte at the University of Exeter, UK. "Right from the start, these hunter-gatherers were looking for transitional zones where they could exploit different environments."

Evidence of this earliest stage of Amazonian life is preserved at several rock shelters in an area of Colombia called the Serranía de la Lindosa. The shelters, which Iriarte and his colleagues have been excavating since 2015, show signs of human habitation stretching back at least 12,600 years. At this time, the Amazon was a few degrees cooler than it is today. But arguably the biggest difference was the presence of large mammals, including giant sloths, elephant-like gomphotheres and huge ungulates. Spectacular rock art in the Serranía de la Lindosa depicts some of these animals, suggesting these megafauna were an important component of the early Amazonians' diet, says Iriarte. What's more, the megafauna had co-evolved with flora that produced fruit large enough to satisfy the hunger of enormous herbivores, thereby encouraging them to disperse the seeds. This fruit – including avocado, cacao and various forms of squash – quickly found a place on the hunter-gatherer's menu too, meaning early Amazonians enjoyed a varied diet.

By 11,600 years ago, most of the megafauna had disappeared, driven to extinction through a combination of human activity and climate change. Then came a new way to obtain food. Instead of simply foraging, some Amazonians began domesticating plants. José Capriles at Pennsylvania State University, Iriarte and their colleagues published the first evidence of this early cultivation in 2020. It comes from the flooded savannahs of the Llanos de Mojos in the Bolivian Amazon. Here, the modern grassy landscape is littered with curious little hills, many about a hectare in size, and each covered in thick vegetation. "We've mapped over 6000 of them," says Capriles.

It turns out these "forest islands" are human-made mounds, some dating back 10,800 years. They sustain forests today because centuries of human activity left their soils more fertile than the surrounding grassland. Capriles suspects they began as temporary camps, but as the soils became enriched by human waste, some of the plants that the foragers ate, including squash and manioc (also known as cassava), began growing there. Then, people started cultivating and ultimately domesticating them.

Gardeners not farmers

Domestication evidently caught on. Soon, as well as growing these short-lived crops in small gardens, the Amazonians were planting groves of long-lived trees, including peach palms and Brazil nuts. In fact, as the scope of these endeavours has become clearer, researchers have begun to recognise the south-west Amazon as an independent centre of plant domestication – one of only five in the world.

At this point, it seems we are on a familiar trajectory. With the traditional model of human cultural evolution as a guide, we might assume the Amazonians would recognise the advantages of growing their own food and become full-time farmers ›

living in permanent settlements. Their populations would then grow and expand across the entire Amazon, and their culture – from farming to languages – would spread far and wide. That isn't what happened.

There is so little evidence of intensive farming in the pre-Columbian Amazon that recent studies conclude there never was a farming revolution in the region like the one that swept across Europe from around 10,000 years ago. There is some evidence for cultural spread – languages in the Arawakan family, for instance, are spoken in many parts of the Amazon – but this diffusion was never particularly strong. The lack of a sweeping wave of farmers might help explain why the Amazon of today retains a mind-boggling diversity of languages – more than 300, including about 50 that are unrelated to any known language, according to Jonas Gregorio de Souza at Pompeu Fabra University, Spain, who has explored the spread of Amazonian languages.

Why did farming fail to take hold? Environmental factors might have played their part – not least, those impoverished Amazonian soils. "They are naturally nutrient poor," says Crystal McMichael at the University of Amsterdam. "It's really hard to grow a big sedentary agricultural society unless you have some type of soil modification."

Amazonian societies did eventually begin modifying the soil and improving its fertility, creating the patches of terra preta that

ASSOCIAÇÃO INDIGENA KUIKURO

JOSE IRIARTE/LAST JOURNEY

Terra preta (top) and rock art (above) shed light on the Amazon's earliest inhabitants

Early Amazonian civilisations

People arrived in the Amazon basin between 27,000 and 13,000 years ago. Growing evidence from sites across the region reveals how they made the rainforest their home

1. Kuikuro city remains in Brazil's Upper Xingu region
2. Rock shelters in Serranía de la Lindosa, Colombia
3. Forest islands and monuments in Llanos de Mojos, Bolivia
4. Tapajó villages of Aldeia and Porto in the central Amazon

researchers have known about for decades. But this didn't happen on a large scale until about 2500 years ago. Research by McMichael and Mark Bush at the Florida Institute of Technology suggests it was only then that human populations began to grow exponentially and people spread freely across the region.

Perhaps more importantly, early Amazonians may not have seen farming as a worthwhile pursuit. They still had access to rivers teeming with fish, and their cultivated gardens and orchards provided plenty of fruit and vegetables. Abandoning this smorgasbord to focus on farming just one or two cereal crops such as maize, which arrived in the Amazon some 7000 years ago, may have had little appeal. This ambivalent attitude might seem surprising given that cultivation of crops has long been seen as a step that leads rapidly and inexorably to full-time farming. But recent archaeological findings have changed this thinking. Even in places where cultivation resulted in intensive farming, including North America and East Asia, it often did so only after a significant lag, sometimes lasting millennia.

We now also know that the adoption of farming wasn't a prerequisite for further social developments: many complex hunter-gatherer societies have existed throughout human history. Instead, societies tend to become more politically, technologically and economically complex by intensifying production of key foodstuffs, because doing so "almost inevitably" encourages the establishment of an elite that can control access to the resource, says Adrian Jaeggi at the University of Zurich in Switzerland.

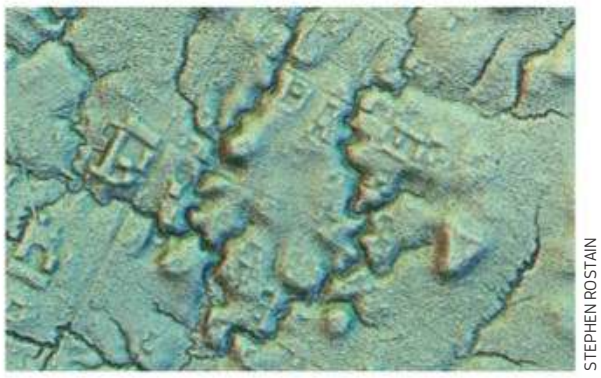
This, rather than a lack of farming, could have created a barrier to the complexification of pre-Columbian Amazonian societies, relying as they did on a wide range of foods distributed across the landscape. Moreover, controlling access to such resources would have been virtually impossible, limiting the opportunity for Amazonian elites to emerge.

At first glance, this seems to fit with the evidence. For instance, beginning about 1000 years ago, the Tapajó people established themselves in the central Amazon, where they built a network of settlements based around two large villages, Aldeia and Porto. Generally, such settlements would serve as seats of power for a ruling elite. Not here. Archaeological excavations in the past 20 years have failed to reveal evidence of a concentration of prestigious goods, says Denise Gomes at the Federal University of Rio de Janeiro, Brazil. Instead, objects of similar social value are found in all Tapajó settlements, both large and small,

suggesting smaller communities retained their autonomy, says Gomes. If the Tapajó are representative of other Amazonian societies, that would explain why the pre-Columbian Amazon is sometimes described as a region in which states or other forms of permanent hierarchical structures failed to emerge.

However, the story turns out to be more complicated. "The groups we see today in the Xingu [region] and elsewhere are very hierarchical despite living in communities of no more than 100 people," says Heckenberger. "And it's because their heritage descended from large, structured and highly organised societies." Support for this assertion doesn't just come from the ancient settlements he was shown by Afukaka. In recent years, remote scanning has revealed similarly large settlements across the Amazon, all built in the past 2500 years after the human population expanded. There is also evidence that some of these settlements were linked by extensive road networks. These were sometimes built on a grid system reminiscent of Manhattan, with straight roads up to 10 metres wide. The scans have found signs of engineering work too, including terraced fields, drainage canals and weirs for trapping fish.

Then there are the monuments. In Bolivia's Llanos de Mojos, these spectacular structures, all made from earth, include stepped platforms and 22-metre-tall pyramids built starting around 1500 years ago. They dwarf the forest islands built by the early Amazonians 10,000 years ago. "Some people would like to think a political system lacking hierarchy can still build such monumental architecture – but I'm sceptical," says Capriles.



STEPHEN ROSTAIN

STEPHEN ROSTAIN

Remote sensing using lidar reveals ancient structures (right) in Ecuador's Upano valley

Complex societies

The complexity of ancient Amazonian societies is also evident in the way they managed the resources available to them. "We're looking at societies that had no stone and no bricks," says Heckenberger. "Everything is organic, and so the industrial demand for wood and grass was tremendous. Not just for house construction, but for portable artefacts – every hammock, every tool." This economic reliance on the rainforest encouraged the ancient inhabitants of the Xingu to develop an intricate landscape management strategy called "garden urbanism", which isn't unique to the Amazon – evidence of similar ways of life is found in other places where civilisations have taken root in tropical forests, including in parts of Africa and Indonesia.

We still don't really know how some pre-Columbian Amazonian societies achieved complexity. One suggestion is that they did it by focusing on, and then intensifying production of, aquatic resources that could be controlled by an emergent elite. Another idea, favoured by Heckenberger, sees hierarchies forming by accumulating political capital. In other words, the authority needed by elites to command the construction of monuments and other engineering projects was rooted in symbolism rather than the accumulation of food surpluses or prestigious goods. Whatever the explanation, the fact that complex societies did emerge confirms a growing realisation that human cultural development – from hunter-gatherer to urban dweller – came in a wider variety of forms than we had assumed. Far from being an anomaly, pre-Columbian Amazon civilisations are a perfect illustration of that paradigm shift. "The more we learn, the less I believe in Amazonian exceptionalism," says Heckenberger.

The Amazon continued to be home to large numbers of people for thousands of years. By the time Europeans arrived in the 16th century, populations in the region had dropped somewhat – perhaps due to disease, says Heckenberger. Nevertheless, the explorers still reported encountering large societies, some so well organised that social elites could assemble an army of 60,000 warriors if the need arose. Such reports were easy to dismiss, however – particularly as Amazonian populations dwindled and fragmented as a result of the expansion of European colonists and the diseases they brought with them – and the idea of the rainforest as a vast natural wilderness took hold.

Now the tide has turned, but Amazonian archaeology is still in its infancy. Undoubtedly, there are many treasures yet to be discovered. With new technology and so much ground to survey, the picture is changing fast. Just last year, remote scans suggested that there are more than 10,000 ancient earthworks still hidden in the Amazon. We can only guess at the secrets they have to reveal. "Anything at this point is conceivable," says Capriles. ▮

Colin Barras is a freelance writer based in Ann Arbor, Michigan

VOTE

‘AI can help democracy by assisting collective intelligence’

Digital democracy pioneer **Audrey Tang** has reimagined politics from the heart of Taiwan’s government. She talks to Laura Spinney

IN 2014, the approval rating of Taiwan’s government was less than 10 per cent. Popular dissatisfaction culminated in the Sunflower Movement, with students occupying legislative buildings to protest a proposed trade deal with China. Three weeks later, their demands were met. A decade on, this is seen as a turning point in Taiwanese democracy.

One group to emerge from the movement was the civic technology cooperative g0v (pronounced “gov zero”), which included the well-known hacker Audrey Tang. g0v proceeded to build a virtual platform for democratic deliberation called vTaiwan. The “v” stands for “virtual”, but it could just as easily stand for “vulnerable”, says Tang. Born with a heart condition that nearly killed her as a child, she has since become the country’s first transgender minister, and she draws parallels between the fragility of her own life and that of democracy.

Tang was invited to join the government in 2016 and set about implementing her vision of “radical transparency”, starting with vTaiwan. After the first covid-19 cases were declared in mainland China in late 2019, she became a central player in the Taiwanese government’s response as a cabinet member for digital affairs. By 2022, Taiwan was being universally lauded for its handling of the pandemic and Tang was given her own ministry, becoming the country’s first minister of digital affairs. In her new book, *Plurality*, she argues that Taiwan – often seen as a potential flashpoint for future global conflict – is now a thriving democracy that has much to teach the world. She stood down from her post in May following January’s elections, which is when we caught up with her.

PAUL RYDING

Laura Spinney: How has technology contributed to an erosion of democracy?

Audrey Tang: Democracy depends on a citizenry being informed and engaged in the conversation, and technology that’s used to censor communication or to conduct surveillance – to make people transparent to the state rather than the other way around – has definitely hurt democracy. Even in places where there is no such top-down pressure, the sheer polarisation that exists online has harmed the discourse that is the backbone of democracy. The backslide has been quite acute in the last few decades as it has become harder for people to see democracy as something they can contribute to, or that delivers.

This is a bumper year for elections globally, and some worry that democracy will take a (further) beating. Do you see it as a watershed moment?

Taiwan successfully overcame the many attacks on our democracy because we had 10 years of experience working against very well-funded adversaries. We know, for example, that collaborative fact-checking inoculates people against disinformation better than looking at a checked fact. For democracies that are less well prepared than ours, yes, I do see this year as a possible watershed in terms of amplifying counter-democratic trends, if only because online discourse has become so central ›

to democratic processes and the artificial intelligence tools that let bad actors manipulate the facts have become accessible to all.

Does AI have the power to save democracy as well as erode it?
Only people – the *demos* in democracy – can save democracy, but AI can help if it's deployed to assist or augment collective intelligence. There are already narrow AI systems that detect online toxicity, for example, but the new generative AI, including large language models, can detect more nuance, including affinity, compassion, curiosity, reasoning and respect. If social media platforms embrace these models to foreground pro-democratic, pro-social conversations, research suggests that people will spend the same amount of time online, but they will engage in conversations that bridge, rather than exacerbate, ideological schisms. They will begin to see democracy as something they can do here and now, rather than something they only experience at election time, or that they delegate to parliamentarians.

In Taiwan, this starts by educating children to be digitally savvy. How is that achieved?
Even before I became a minister, I was a member of the committee that advised the government on curricular reform. The overhaul took effect in 2019, and our new curriculum has now been deployed to all primary schools [ages 6 to 12]. Instead of a one-size-fits-all education, based on critical consumption of information and standardised tests, the new curriculum emphasises autonomy, interaction and the common good. Co-creation replaces literacy at the core of it. I think the results speak for themselves. Surveys show that vTaiwan now leads the world in civic education.

Taiwan has been criticised because the government is free to dismiss policy proposals, and often does. How do you judge vTaiwan's impact?
vTaiwan served as a proof of concept that, using open-source technology alone, civil society can deliberate policy matters in a fully participatory way that leaves nobody behind. That is important given that 10 years ago, the administration was enjoying an approval rating of 9 per cent and people automatically distrusted anything it said or asked. To begin with, the platform addressed mainly digital issues, but it ended up delivering quite impactful policies – for the regulation of the ride-hailing company Uber, for example. And the project later broadened its scope to non-digital issues, such as consultations for the Open Parliament Action Plan [which aims to bolster democracy through transparency, openness, participation, digitisation and literacy]. vTaiwan helped rebuild legitimacy.

> "Only people – the *demos* in democracy – can save democracy"

How do the Join platform and your latest initiative, Alignment Assemblies, move things on?
Join is a government-run – as opposed to a civil society-run – platform. It was launched a year after vTaiwan, and its most important function is to serve as a petition platform. Anyone who gathers 5000 signatures for a proposal can force a ministerial response.

Alignment Assemblies are conversations designed to steer the development of AI in ways that benefit society. It takes on board three lessons that we learned from the implementation of vTaiwan. First, we reach out to hundreds of thousands of people via SMS from what they know to be a government number. Second, once we have chosen a representative sample of several hundred citizens, we ask them to meet online in video chat rooms with AI facilitators – something that only became possible with recent advances in conversational AI. Both those measures have massively increased

REUTERS/ANN WANG

Taiwan had a scoreboard ranking people's preferred covid-19 vaccines

REUTERS/TOBY CHANG

A decade ago, dissatisfaction with Taiwan's government spawned the Sunflower Movement

inclusivity, including of senior citizens. Third, we summarise the conversation using AI. A recent Alignment Assembly on the accuracy, reliability and consistency of information led, in just a few months, to an anti-fraud act that is currently awaiting deliberation in parliament.

How did your digital approach help in Taiwan's response to the covid-19 pandemic?

Around the world, polarisation over vaccines hurt many more people than was necessary, but in Taiwan there was no anti-vaccine faction. That isn't because Taiwanese people are homogeneous, it's because we turned the conversation into a "my vaccine is better than your vaccine" race. We had a national online scoreboard where we kept track of people's preferences for four vaccines by age bracket. It became a friendly competition, as between rival sports teams.

The idea, then and now, is to anticipate a conspiracy theory and prebunk it, instead of trying to debunk it after the fact when it might be too late. Prebunking works like inoculation: a weaker virus takes hold so a more potent one can't. We applied the same strategy before the general elections in January to scotch the conspiracy theory that they would be rigged.

Did digital democracy have a positive impact on those elections?

Definitely. After the election, hate across party lines reached a historic low, and that's despite Taiwan being the most targeted place in the world for disinformation and interference aimed at increasing polarisation. We have playbooks against such interference, including collaborative fact-checking and prebunking of conspiracy theories, so that it backfires and actually increases solidarity across Taiwanese people. The upshot is that, after the election, all three parties and their supporters feel that they have won a little bit. Our radically transparent approach to ballot-counting helped too: votes, which were on paper, were read out in front of observers with cameras.

Have other countries asked for your help in introducing digital democracy?

Very much so. I'm about to leave for a book tour in Europe, where I'll meet my counterparts in European governments as well as civic society groups. I'll spend a few days in Finland, which is one of the few countries in Europe to use the collaborative sense-making tool Polis for national consultation, as vTaiwan does. Digital ministers form an assembly of sorts, with experimental platforms all around the world, including Policy Lab in the UK and sitra in Finland.

Taiwan has a very high level of digital inclusivity. Could these processes work in other countries?

From 2016, we insisted that mobile broadband was a human right and the penetration rate of that alone was more than 80 per cent in 2022 – up from 67 per cent six years earlier. That's even before you consider fixed broadband. We are one of the top countries in the world when it comes to internet inclusivity. But yes, what we have done is absolutely feasible in other countries. The point is that we bring technology to where people are. We're not asking them to adapt to the technology – and offline options remain available. Accessibility is our top priority.

As a hacker-turned-minister, someone who has tried to renew democracy from the inside, is your ultimate goal to bring down the existing system?

I'm a Taoist, meaning that I don't think in terms of bringing things down. I prefer Richard Buckminster Fuller's metaphor in which an individual affects society like a trim tab – the tiny rudder that steers the actual rudder that steers the ocean liner. I don't steer, I nudge. I want to persuade people to think of democracy as a social technology and to invent new ways of living together. The documentary *Good Enough Ancestor*, which is based on my book and my life, makes it clear that for me, it isn't about trying to solve everything or closing down possibilities. It's about opening them up for future generations, who will have different challenges and different tools, and harnessing diversity through co-creation. The same word in Taiwanese means "digital" and "plural". I always thought of myself as both digital minister and minister of plural affairs. ▮

Laura Spinney is a writer based in Paris, France

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Mathematics of life

A piece of cake

Whether you are dividing a cake or a coastline, maths can help make sure everyone is happy with their share, says **Katie Steckles**

Katie Steckles is a mathematician, lecturer, YouTuber and author based in Manchester, UK. She is also adviser for *New Scientist*'s puzzle column, BrainTwister. Follow her @stecks

Mathematics of life reveals the mathematical ideas and shortcuts behind everyday situations

Next week
Debunking gardening myths

ONE big challenge in life is dividing things fairly. From sharing a tasty snack to allocating resources between nations, having a strategy to divvy things up equitably will make everyone a little happier.

But it gets complicated when the thing you are dividing isn't an indistinguishable substance: maybe the cake you are sharing has a cherry on top, and the piece with the cherry (or the area of coastline with good fish stocks) is more desirable. Luckily, maths – specifically game theory, which deals with strategy and decision-making when people interact – has some ideas.

When splitting between two parties, you might know a simple rule, proven to be mathematically optimal: I cut, you choose. One person divides the cake (or whatever it is) and the other gets to pick which piece they prefer.

Since the person cutting the cake doesn't choose which piece they get, they are incentivised to cut the cake fairly. Then when the other person chooses, everyone is satisfied – the cutter would be equally happy with either piece, and the chooser gets their favourite of the two options.

This results in what is called an envy-free allocation – neither participant can claim they would rather have the other person's share. This also takes care of the problem of non-homogeneous objects: if some parts of the cake are more desirable, the cutter can position their cut so the two pieces are equal in value to them.

SAY-CHEESE/GETTY IMAGES

What if there are more people? It is more complicated, but still possible, to produce an envy-free allocation with several so-called fair-sharing algorithms.

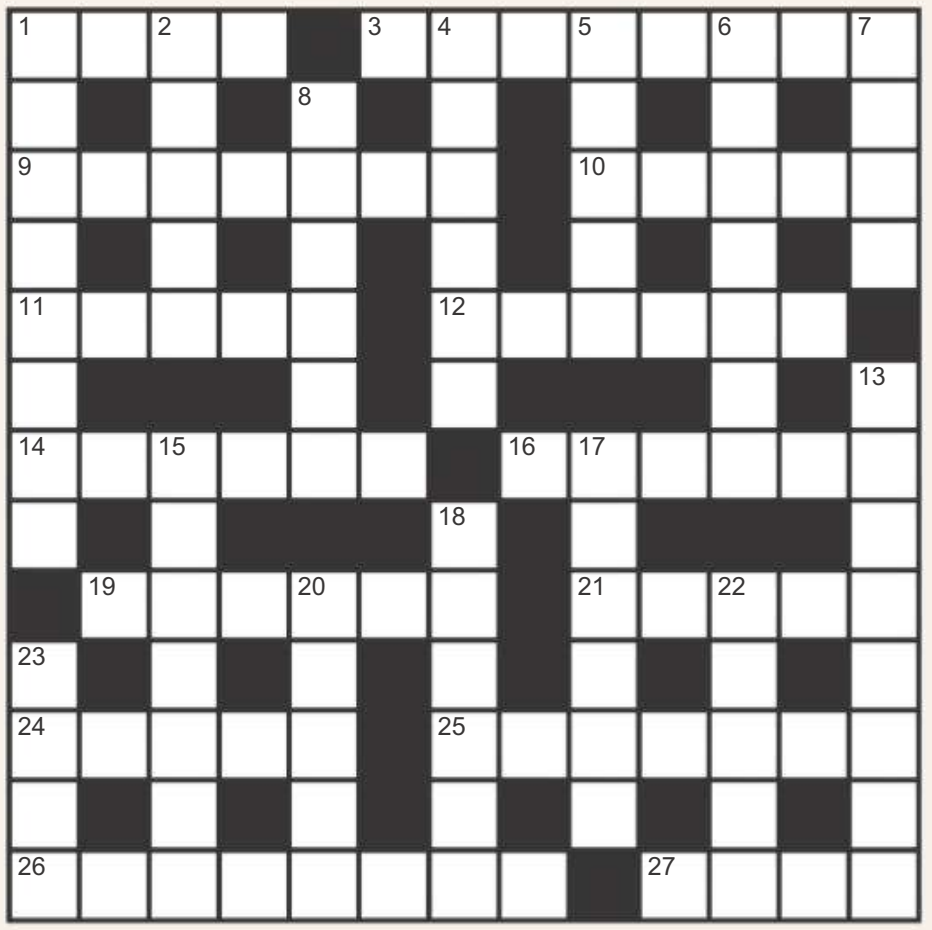
Let's say Ali, Blake and Chris are sharing a cake three ways. Ali cuts the cake into three pieces, equal in value to her. Then Blake judges if there are at least two pieces he would be happy with. If Blake says yes, Chris chooses a piece (happily, since he gets free choice); Blake chooses next, pleased to get one of the two pieces he liked, followed by Ali, who would be satisfied with any of the pieces. If Blake doesn't think Ali's split was equitable, Chris looks to see if there are two pieces he would take. If yes, Blake picks first, then Chris, then Ali.

If both Blake and Chris reject Ali's initial chop, then there must be at least one piece they both thought was no good. This piece goes to Ali – who is still happy, because she thought the pieces were all fine – and the remaining two pieces get smooshed back together (that is a mathematical term) to create one piece of cake for Blake and Chris to perform "I cut, you choose" on.

While this seems long-winded, it ensures mathematically optimal sharing – and while it does get even more complicated, it can be extended to larger groups. So whether you are sharing a treat or a divorce settlement, maths can help prevent arguments. ▮

These articles are posted each week at newscientist.com/maker

Cryptic crossword #139 *Set by Trurl*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 BBs, possibly, made from unfinished metal (4)
3 Starting point is low part for audience (8)
9 Putting up with wrinkly type going first (7)
10 Yank shortly returning to US with disease (5)
11 Pack animal for going round a shopping centre (5)
12 Astute point smothered in scrap (6)
14 Emily shaken by noisy opening (it's about nerves) (6)
16 Swap this to make mince of Ming – space pilots know it well! (1-5)
19 Saga directed partly in African city (6)
21 Minor theorem from middle of Trollope's classic novel (5)
24 Trurl's a Greek character heading west to get flavour (5)
25 Mob has trouble over nervy gatherings (7)
26 Smoked fish dish, e.g., reeked awfully (8)
27 Killer for cash? Not entirely (4)

DOWN

1 Going both ways on road, green skylark could get stuck here? (8)
2 Girlfriend in Madrid with old PC (5)
4 Gold rush is impressive! (6)
5 Einstein's first rule broken by maths whizz (5)
6 Wore pin rudely on throne (2,5)
7 Vowels voiced in comfort (4)
8 Gallium, iodine, lithium and potassium blended in capital (6)
13 Vessel holding largely corrupted sparkling wine (4,4)
15 State, in French, where hormones may come from (7)
17 Ladder is initially omitted from means of rescuing cat (6)
18 City fever suppressed by propaganda department (6)
20 Velcro opener missing from contraption to remove rocks? (5)
22 It may be ground in concentration (5)
23 Banner version of headline, to begin with, large-scale but not bold (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #259
set by Bethan Ackerley

1 Who discovered superconductivity in 1911?

2 Periodic comets take fewer than how many years to orbit the sun?

3 Which elementary particles mediate the strong interaction between quarks?

4 "The Martians" were a group of scientists who emigrated to the US from which European country in the 20th century?

5 T-cells, B-cells and natural killer cells are all subtypes of which kind of white blood cell?

Answers on page 47

BrainTwister
set by Mary Ellis
#27 Dancing decimals

1/3 can be written as 0.33333... (with a string of 3s going on forever) and 4/9 can be written as 0.44444... . We call these recurring decimals.

Use a calculator to see what 1/11, 2/11 and 3/11 are as decimals. Can you predict what 7/11 and 10/11 will be?

There is a different type of pattern in the sevenths: calculate 1/7 and 2/7, then try to predict what 3/7, 4/7, 5/7 and 6/7 will be.

Can you also find any patterns in the multiples of 1/13? (It is similar to the sevenths, but you might need to calculate more than two of the fractions to be able to predict the rest.)

Solution next week

Going green

Why didn't green fur evolve among mammals, when there are birds with green plumage and reptiles with green skin?

Herman D'Hondt
Sydney, Australia
Reptiles and birds have three types of colour-sensing cone cells in their retinas that are each sensitive to a specific colour – usually, there are red, green and blue receptors. They also have a fourth type that works in the ultraviolet range. Mantis shrimp can have up to 16 different types of cones: what they use them for is anybody's guess.

When mammals first evolved from reptiles, they lost one or two of these receptors. This may have been because early mammals were mostly active at night or underground, while dinosaurs controlled the land during the day. Since then, almost all mammals, including marsupials and monotremes, have had only two types. It is only humans and primates native to Africa, Asia and Europe that regained a third type.

Having only two types of receptor gives most mammals red-green colour blindness. As a result, they can't tell the difference between red and green.

"Some sloths are green, but not because they are growing green fur, but rather because their fur is host to green algae"

Adding genes to produce green fur would come at an additional cost. Because evolution tends to select the least costly option, that didn't happen. I guess evolution could have given mammals green fur instead of red, but mutations are random.

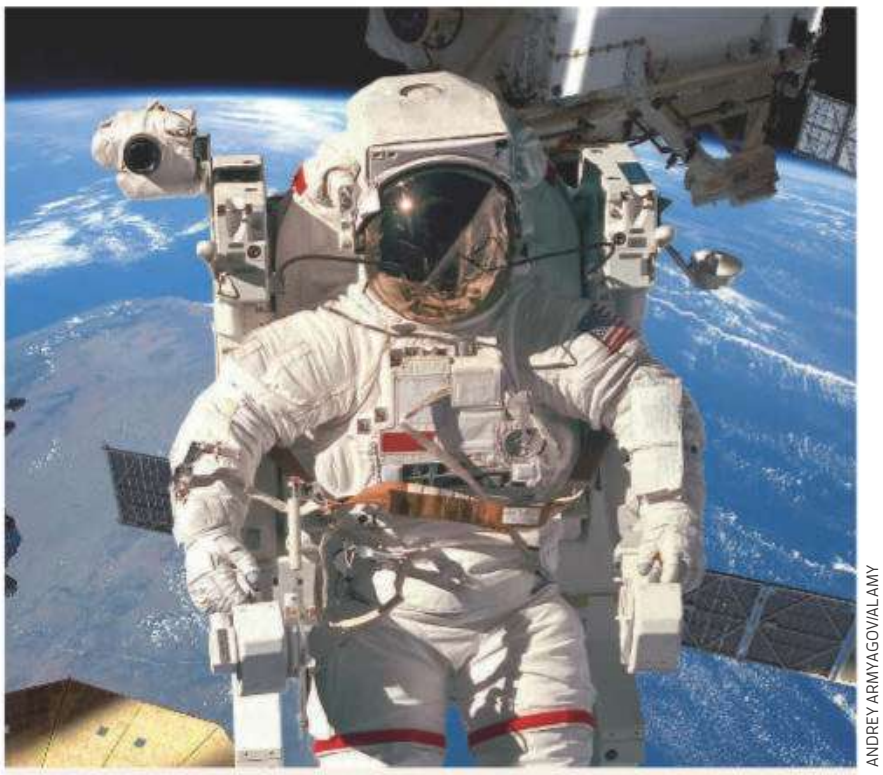
Having said all that, it is worth noting that some sloths are green. However, that isn't because they are growing green fur, but rather because their fur is host to symbiotic green algae. This may serve as camouflage when moving around in trees.

Jonathan Wallace
Newcastle upon Tyne, UK
For any particular trait to evolve, two things need to happen. First, genetic mutation needs to create the code for the trait in question so that individuals enter the population displaying that trait. Secondly, the trait needs to confer a competitive advantage over individuals with other phenotypes such that those with the trait have more young surviving in following generations.

With respect to the first of these, it is important to recognise that mutations occur at random and not as a purposeful response to a design problem. It is possible that a mutation (or combination of mutations) coding for green fur simply hasn't happened.

With respect to the second, it is conceivable that even if green fur has appeared at some time or another, it failed to give any significant advantage to its bearers (or may have conveyed a counteracting disadvantage). Anyone who has tried to see mammals in the wild will know that many of them hide away extremely effectively, so it isn't clear that being green would necessarily be an improvement.

Andrew Taubman
Perth, Western Australia
Maybe green fur did evolve, but, it being such excellent camouflage, we haven't been able to see those creatures?



ANDREY ARMYAGOV/ALAMY

This week's new questions

Life in space **If time changes as a result of the speed of space travel, do the cells in an astronaut's body still multiply at the same rate?** ***Lyn Williams****, Cilffriw, Neath Port Talbot, UK*

Time for pizza **There is a pizza restaurant 300 metres down the road from my house. Does it take more energy for me to skip to it or run to it?** ***Jessica Lamond (age 5)****, London, UK*

Do an astronaut's cells multiply at a different rate to normal when they are in space?

Room to remember

If someone could have their life extended with no limit, would their brain eventually run out of storage space?

Hillary Shaw
Newport, Shropshire, UK
Memory storage can't be in units of less than one atom, so if our brains stored memories linearly, like book text, at some point it would be full.

However, we don't do this. We have memory hierarchies, so I don't need to remember everything in my encyclopedias, just where I put them, what concepts/words those 26 or so little characters make and the order of the alphabet.

Likewise, I can write my life events down in a diary. If I can't remember where I put all my books, I can make a list or order them some way. The internet gives me access to even more knowledge if I remember how to switch the computer on. So I only need remember a few thousand words (or where I keep the dictionary) to open up infinitely extendable, readily accessible memories, even if I live for a trillion trillion years.

Robert Law
Hong Kong, China
What is memory? As far as we know, it is a collection of neurocircuits with multiple neurons participating, which has the specific function of recording/storing events/knowledge in the past that can be retrieved at any time – even during our sleep, creating dreams.

If you think about it, during your lifetime, from birth to, say, 80, the amount of day-to-day information that is fed to your brain is simply (and literally) mind-boggling. If the brain were a simple computer, it would have physically run of storage space

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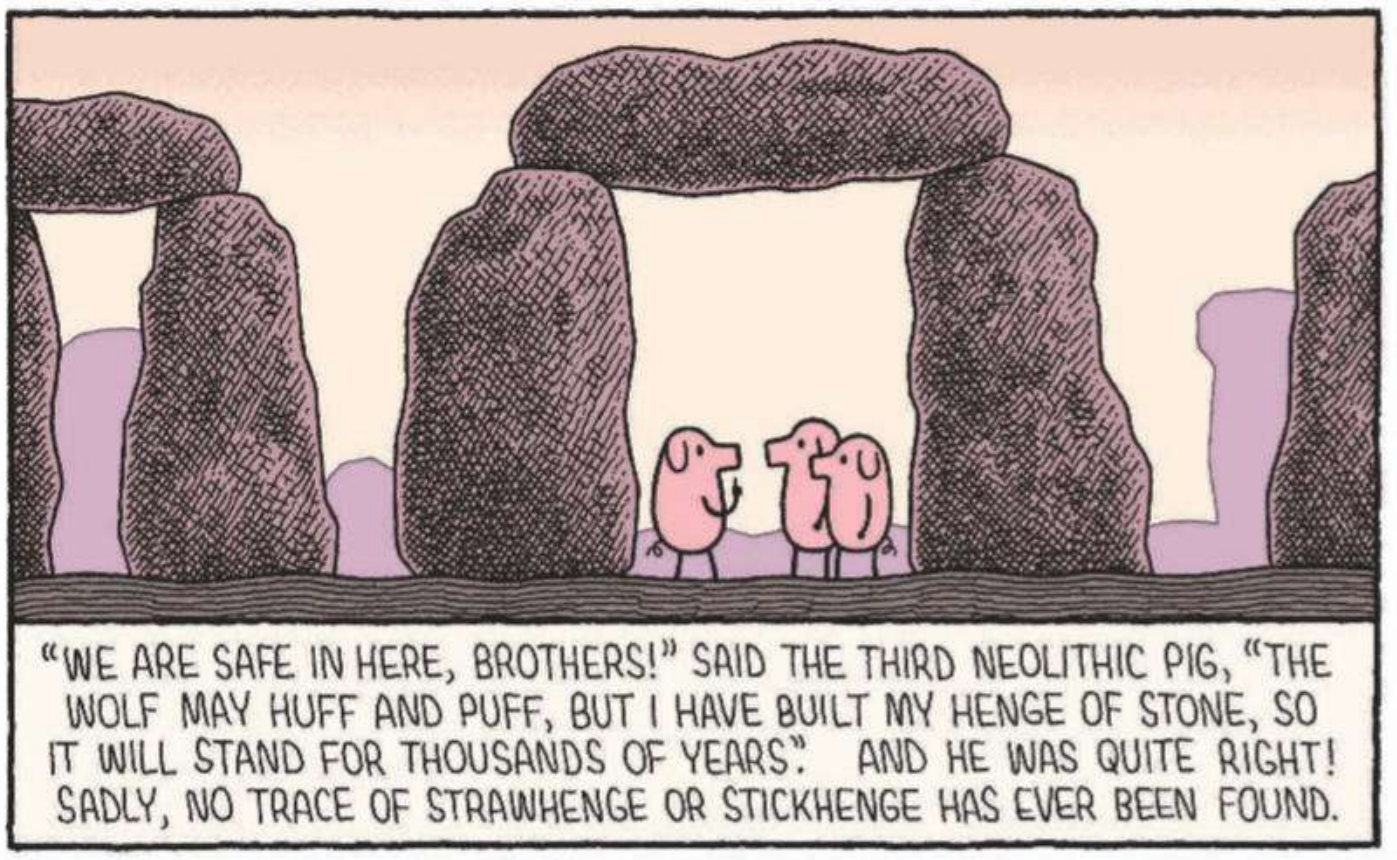
Tom Gauld
for New Scientist


"WE ARE SAFE IN HERE, BROTHERS!" SAID THE THIRD NEOLITHIC PIG, "THE WOLF MAY HUFF AND PUFF, BUT I HAVE BUILT MY HENGE OF STONE, SO IT WILL STAND FOR THOUSANDS OF YEARS". AND HE WAS QUITE RIGHT! SADLY, NO TRACE OF STRAWHENGE OR STICKHENGE HAS EVER BEEN FOUND.

when you were a few years old. Therefore, your brain must function in a way where all the information that is being fed into it is constantly deleted after a short period of time. To remember something, you have to repeatedly feed that same information (think of revising for exams) to your brain.

This should mean that, no matter how old you get, you will never run out of storage space because old (and not-so-old) memories are constantly being deleted to make way for new ones.

However, when we get old, we tend to remember the past more than recent events. Could that be a sign of the brain ageing and running out of storage space, so there is no more space for short-term memories?

This may be true in cases of people with early dementia. Those affected may not remember whether they have just eaten a meal, but they can vividly recall events that happened when they were very young.

So, the answer to the question

"If the brain were a simple computer, it would have physically run out of storage space when you were a few years old"

is: as long as the brain remains healthy just like the rest of the body, it won't run out of storage space, but an ageing brain may.

Electric dreams

Is it more environmentally friendly to keep my 23-year-old petrol car or to scrap it and buy a new electric one? I drive about 8000 kilometres a year and am quite old, so my car may outlast me. (continued)

Frank Brophy
Weston-super-Mare, Somerset, UK
There is a lot of misinformation on how environmentally friendly electric vehicles are. If you assume electricity is generated mostly from fossil fuels, it would indeed take many years for the emissions from making a new EV to break even with those of an existing conventional vehicle. An EV in Europe pays off its carbon debt after around 18,000 kilometres (11,000 miles), according to the International Council on Clean Transportation. In the US, this takes a bit longer, although it is better in some states than others, depending on the fuel mix.

So if you are going to drive that petrol car for more than two years, better to replace it with an EV as soon as you can. Even better, get rid of it immediately and preferably scrap it, rather than let someone else drive round in it emitting more carbon dioxide (plus all those other particulates and oxides).

In the UK, the carbon intensity of the electricity grid is continuously being reduced, so over future years the electricity used to charge an electric car will have a lower carbon footprint. Additionally, many EV drivers charge their cars at night when the grid is cleaner and cheaper (or they may have solar panels), further decreasing the carbon used to generate the electricity used. ▮

Answers

Quick quiz #259 *Answers*

1 Heike Kamerlingh Onnes

2 200 years

3 Gluons

4 Hungary

5 Lymphocytes

Quick crossword #161 *Answers*

ACROSS 1 Gallbladder, **7** Fry, **9** Extra, **10** Silica gel, **11** Thirtieth, **12** Servo, **13** Uveitis, **15** Nail, **18** Blue, **20** Conical, **23** Quipu, **24** Ukrainian, **26** Emaciated, **27** Volta, **28** Kea, **29** Markov chain

DOWN 1 Great auk, **2** Lattices, **3** Bract, **4** Abscess, **5** Dolphin, **6** Recession, **7** Figure, **8** Yellow, **14** Tellurium, **16** Achillea, **17** Plantain, **19** Equator, **20** CB radio, **21** Squeak, **22** Cicada, **25** IMViC

#26 Up and down *Solution*

30 × 30 is bigger. Starting with 30 × 30, we can remove one 30 to get 29 lots of 30. Now, we can add another 29 to get 31 lots of 29, or 31 × 29. Since we removed 30 and added 29, we have made the product smaller.

The same argument works for numbers other than 30. Algebraically, $(n+1)(n-1) = n^2 - 1$, which is always less than n^2.

If instead of 1, we chose to add and subtract k, the product is $(30+k)(30-k) = 30^2 - k^2$, so the difference will be k^2.

Nest: still abandoned

Brace yourselves. That abandoned bird's nest is still seated in the mouth of the large, ancient, carved stone human face hanging high on a wall in the northernmost corner of the outdoor garden known as "Michelangelo's Cloister" in the National Roman Museum in Rome, reports the University College London (UCL) professor who discovered it while visiting the museum this past April then reported it to a colleague who is the director of one of the Netherlands's great natural history museums, who visited the National Roman Museum the next day and asked officials if he could remove the nest, saving them the trouble of destroying or discarding it, and bring it back to his museum in Rotterdam to add to a collection of biological curiosities, a request greeted with eager gratitude by two officials of the Rome museum but then refused with operatic rage by a third official who happened upon the scene when the first two officials fetched a ladder for the Dutch museum official to use to climb up and remove the until-then-unnoticed nest from the open mouth of the sculpture and who declared that not a twig, not a pebble, must ever leave his museum.

You can see a photograph of the offending nest in the Feedback of 8 May.

In early June, the UCL professor made a quiet return visit to the National Roman Museum, following which he immediately sent an "It's still there" report to Feedback.

Feedback would now, more than ever, enjoy receiving reports from future visitors to Michelangelo's Cloister to observe whether the empty nest (call it an "amuse-bouche", if you like) is still cuddled in the statue's mouth.

Not your way

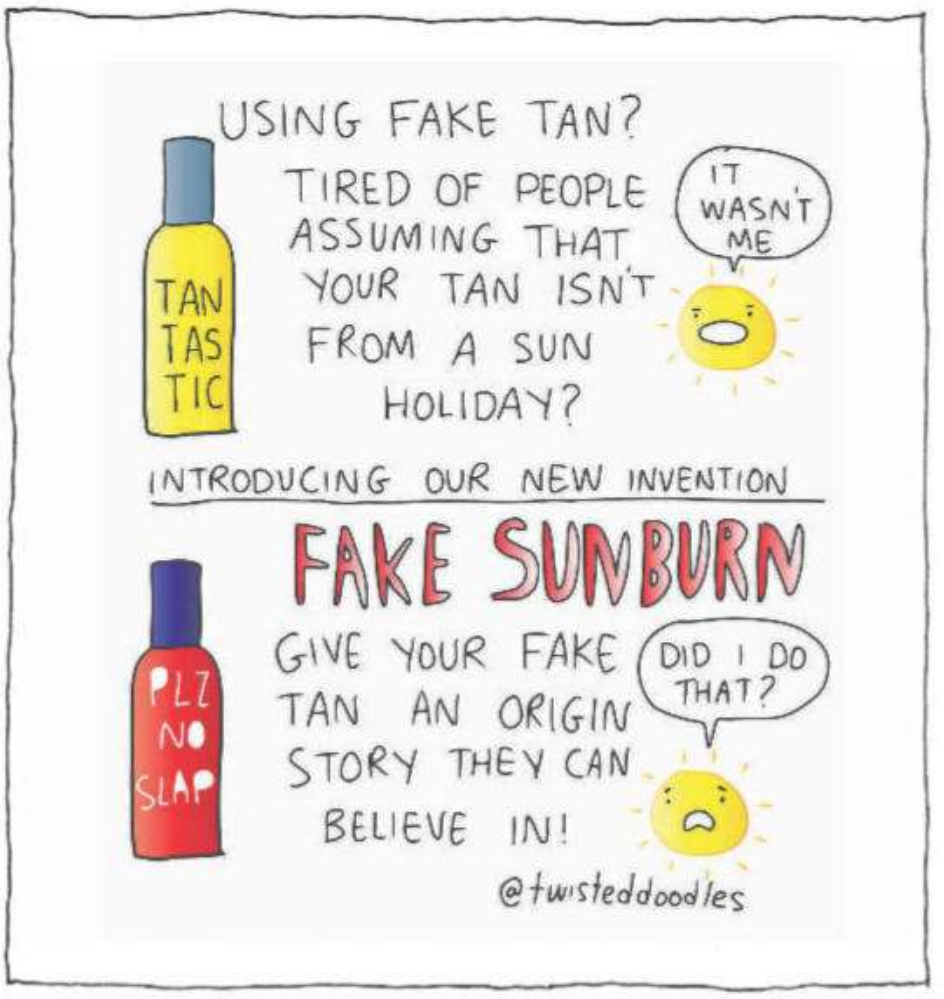
Reader Ashok Khushalani sends a contribution to Feedback's collection of inspirationally commendable organisation slogans that, not necessarily obviously to the public, were supplanted, superseded or apparently abandoned (18 May). The classic examples are IBM's "THINK" and Google's "Don't be evil".

Khushalani mourns the loss, in daily experience, of Burger King's slogan "Have it your way". This absence, he suggests, has implications.

If you know of a notable highly touted, now-warehoused, slogan, don't be evil and keep it to yourself.

Instead, please send it, along with documentation, to "Mourning dead slogans", c/o Feedback.

Twisteddoodles *for New Scientist*


USING FAKE TAN?
TIRED OF PEOPLE ASSUMING THAT YOUR TAN ISN'T FROM A SUN HOLIDAY?
TAN TAS TIC
IT WASN'T ME
INTRODUCING OUR NEW INVENTION
FAKE SUNBURN
GIVE YOUR FAKE TAN AN ORIGIN STORY THEY CAN BELIEVE IN!
PLZ NO SLAP
DID I DO THAT?
@twisteddoodles

Got a story for Feedback?

Send it to feedback@newscientist.com
or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

A limp theory

Two things – the North American fascination with rod-shaped items and the human habit of proposing theories then shooting them down – come together in a study called "Size matters? Penis dissatisfaction and gun ownership in America".

Reader Matthew Hall sent a copy to Feedback.

"To our knowledge, this is the first study to formally examine the association between penis size and personal gun ownership in America," write Terrence D. Hill and his colleagues in Texas and Florida. "Our findings fail to support the psychosexual theory of gun ownership."

The same team, plus or minus two researchers, had at it in 2021 with a related study called "Sexual dysfunction and gun ownership in America: When hard data meet a limp theory".

They threw cold water on an often-heated public discussion, saying: "Our key finding is that men experiencing [sexual dysfunction] are no more likely to own guns than men without SD."

Basta, they seemed to say in the earlier paper. This didn't prevent them from continuing to write about it. *Basta*: "Ultimately, these kinds of discussions are counterproductive for society because they distract us from the observable realities of penis dissatisfaction and gun ownership."

Sense of smell

Mention of a celebrity pathologist's inability to smell smells (12 June) aroused reader John Adams to think about his own medical-professional journey:

"Regarding Sir Bernard Spilsbury's defective sense of smell, as a medical student I was told that this is common amongst pathologists because they are exposed to large quantities of formaldehyde vapour which destroys the olfactory nerves. This was one reason I avoided this speciality, the other being that I like my patients to answer back."

A similar, though milder, preference for conversation, Feedback is told, leads some people to choose dentistry.

Telltale titles

Ideally, the title of a scientific report clearly summarises the whole thing. To encourage this practice, Feedback is compiling a collection called The Title Tells You Everything You Need to Know.

Savour, please, two examples. "Man's fractured sternum was probably due to snake's weight when it fell" appeared in the *British Medical Journal* in 1997. "Experimental replication shows knives manufactured from frozen human feces do not work" graced the *Journal of Archaeological Science: Reports* in 2019.

If you find an equally striking example, please send it, with citation details, to: "Telltale titles", c/o Feedback. ▮

Marc Abrahams

Glow-up

With a JJ04 movement capable of precisely plotting each phase of the moon for 128 years, the C1 Moonglow has always had allure. Now, it exerts an even greater gravitational pull. The twin Globolight orbs, which wax and wane across the starry, sapphire dial are more three-dimensional. And, instead of glowing green, they gleam a cool, bright blue - thanks to souped-up Super-LumiNova. (Which also lights up its orbiting date wheel, for truly stellar nocturnal legibility.) Other lustrous features include a 40.5mm LightCatcher™ case, polished lug facets and optional five-link Consort™ bracelet. Even its price is illuminating: from just £1,995 on leather.

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